FUJITSU SEMICONDUCTOR
ASSP MANUAL

AM32-10827-1E

ON-SCREEN DISPLAY CONTROLLER

ASSP FOR SCREEN DISPLAY CONTROLLER

MB90092

USER'S MANUAL

FUJITSU

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CHAPTER 1 DESCRIPTION

Chapter 1 describes the features and internal circuit blocks of the MB90092.
The MB90092 is the display controller for displaying text and graphics on the TV screen.
The MB90092 incorporates display memory (VRAM), a font memory interface, and a video signal generator, allowing text and graphics to be displayed in conjunction with a small number of external components.

1.1 Features
1.2 Block Diagram
1.3 Internal Circuit Blocks
1.4 Example of Application Circuit

1.1 Features

Main Screen Display

- Screen display capacity: 24 characters × 12 lines (up to 288 characters)
- Character sizes: Standard, double width, double height, double width × double height, quadruple width × double height (Setting possible for each line)
- Display position control: Horizontal display start position: Set in 1/3-character units
  Vertical display start position: Set in raster units
  Line spacing control: Set in raster units (0 to 15 rasters)
- Display priority control: Capable of controlling display priority over the sub-screen (for each line)

- **Normal mode display**
  - Normal character exclusive display mode:
    Screen capacity: 24 characters × 12 lines (up to 288 characters)
    Character types: 8192 different characters (8 M addresses)
  - Character display:
    Character dot configuration: 24 × 32 dots (per character)
    Character color: 8 colors (for each character) × 4 phases (for each line)
    Character background color: 8 colors (for each character)
    Display mode: Selectable from among the pattern background/solid-fill backgroundor/ no background modes

- **Extended graphics mode display**
  - Mode for displaying individually selected, normal and graphic characters mixed:
    Screen capacity: 24 characters × 12 lines (up to 288 characters)
    192 horizontal dots × 384 vertical dots (entire screen)
    Character types: 16384 different characters (16 M addresses)
  - Normal character display:
    Character dot configuration: 24 horizontal dots × 32 vertical dots
    Character color: 8 colors (for each character) × 4 phases (for each line)
    Line background color: 8 colors (for each line)
    Display mode: Selectable from among the pattern background/solid-fill background/ no background modes Shaded background display available (set for each character)
  - Graphic character display:
    Character dot configuration: 8 horizontal dots × 32 vertical dots
    Character color: 8 colors (for each dot) × 4 phases (for each character)

Sub-Screen Display

Screen display position: Settable horizontally and vertically in 2-dot units

- **Normal screen mode**

	Screen capacity:	32 characters × 12 lines (up to 384 characters) 256 horizontal dots × 384 vertical dots (graphics characters only) (The actual display screen depends on the television system and dot clock frequency. Normal character/ graphic character display selectable for each line (Header display character code is specified for each line.)
	Character string length:	Selectable from among 1, 2, 4, 8, 16, 24, and 32 digits
• Normal character display:	Character dot configuration:	24 horizontal dots × 32 vertical dots
	Character color:	8 colors (for each line)
	Pattern background color:	8 colors (entire screen)
• Graphic character display:	Character dot configuration:	8 horizontal dots × 32 vertical dots
	Character color:	8 colors (for each dot) × 4 phases (for each line)

- **Full-screen mode**

	Screen capacity:	32 characters × 16 lines (up to 512 characters) 256 horizontal dots × 512 vertical dots (The actual display screen depends on the television system and dot clock frequency.)
	Virtual screen capacity:	Mode A: 32 characters × 16 lines (× 32 screens) 256 horizontal dots × 512 vertical dots
		Mode B: 512 characters × 32 lines 4096 horizontal dots × 1024 vertical dots
• Normal character display:	Character dot configuration:	24 horizontal dots × 32 vertical dots
	Character color:	8 colors (set for the entire screen)
	Pattern background color:	8 colors (set for the entire screen)
• Graphic character display:	Character dot configuration:	8 horizontal dots × 32 vertical dots
	Character color:	8 colors (for each dot) × 4 phases (set for the entire screen)

Screen Background Display

Screen background color: 8 colors (set for the entire screen)

Analog Inputs

- Composite video signal input
- Y/C-separated inputs

Analog Outputs

- Composite video signal output
- Y/C-separated outputs

Digital Outputs

- G (Green), R (Red), and B (Blue) output
- VOC (character) output, VOB (character + background) output
- Characters, character background, line background, and screen background each capable of being displayed in eight colors

Internal Synchronization Control (Video Signal Generator)

- Internal video signal generator supporting the NTSC and PAL systems
- Interlaced/noninterlaced display selectable

External Synchronization Control

- Separated sync signal input/composite sync signal input selectable

External Interface

- 8-bit serial inputs (3 signal input pins)
  Chip select: $\overline{\text{CS}}$
  Serial clock: SCLK
  Serial data: SIN

Package

- QFP-80

Miscellaneous

- Internal power-on reset circuit

1.2 Block Diagram

Figure 1.2-1 is a block diagram of the MB90092.

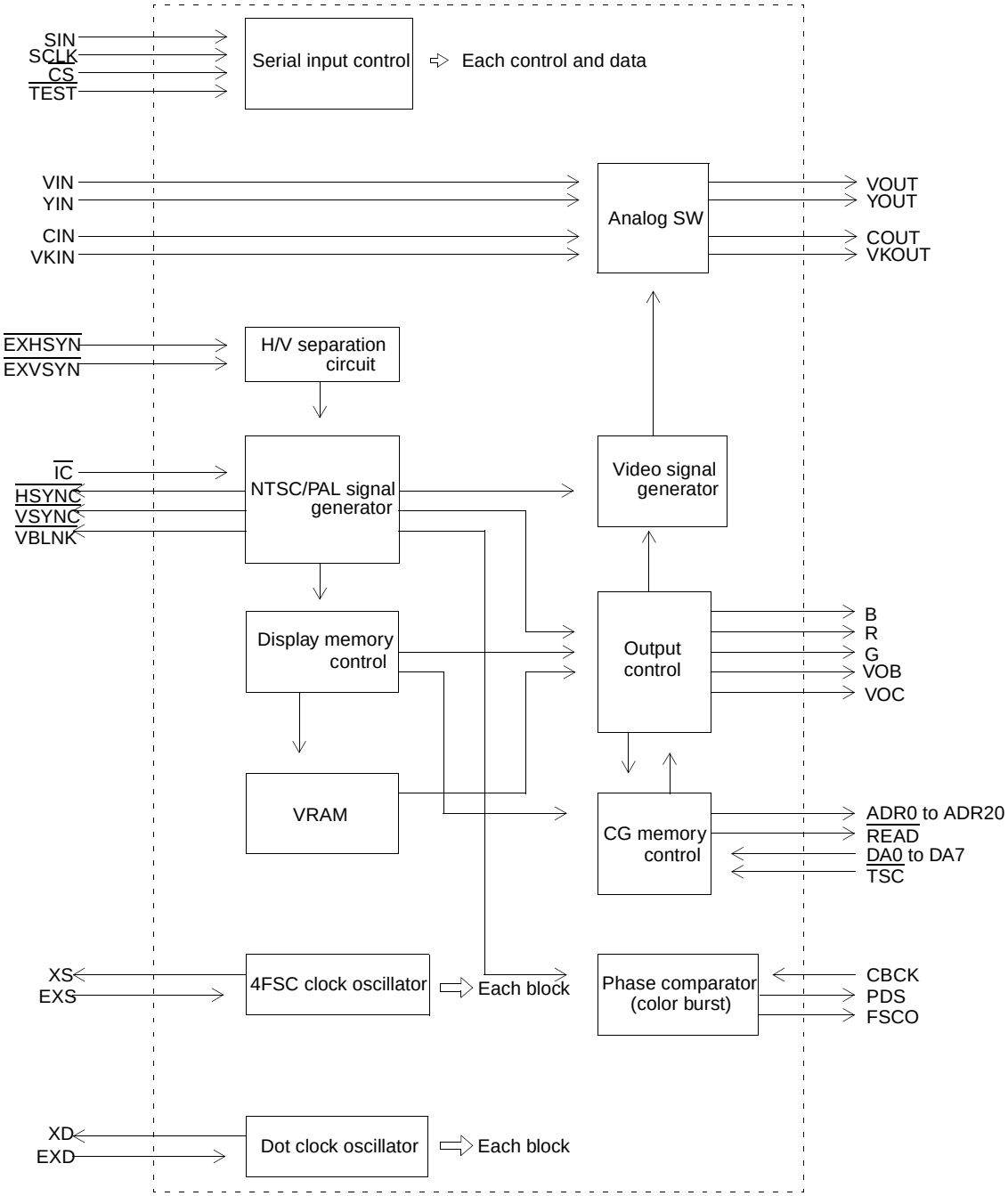


Figure 1.2-1 Block Diagram

1.3 Internal Circuit Blocks

(1) Serial input control block

This block receives the commands and data input to the MB90092 via 8-bit serial transfer. The command decoder decodes the received command and directs data to each register.

(2) H/V separator block

This block separates the input composite sync signal into a horizontal sync and a vertical sync signal by the comparator.

(3) NTSC/PAL signal generator block

This block generates an NTSC system or PAL system timing signal.

(4) Display memory control block

This block generates timing for display operation to control the operation of each block.

(5) Display memory (VRAM) block

Display memory (VRAM) is used to store character code, character color, character background color, attribute, and line control information.

(6) Font memory control block

This block controls the external font memory. It outputs a font memory address and the $\overline{\text{READ}}$ signal and reads the font data.

(7) Output control block

This block processes the character data from CGROM for character border, background, etc. to generate a character signal.

(8) Video signal generator block

This block generates a video signal and a character luminance signal when operating under internal sync control.

(9) Analog switch block

This block synthesizes an externally input video signal or an internally generated video signal with the internally generated character signal.

(10) 4FSC clock oscillator block

This block generates a 4FSC clock that serves as the basic block of the MB90092's sync signal system.

(11) Dot clock oscillator block

This block generates a dot clock that serves as the basic block of the MB90092's memory timing system.

(12) Phase comparison circuit (color burst) block

This block compares the phases between internally generated color burst signals and external input color burst signals.

1.4 Example of Application Circuit

Figure 1.4-1 shows an example of an application circuit using the MB90092. This is a quite basic and simple circuit example not considering the character display quality but considering the numbers of external components.

Note that the precise circuit configuration may vary depending on the system or components used.

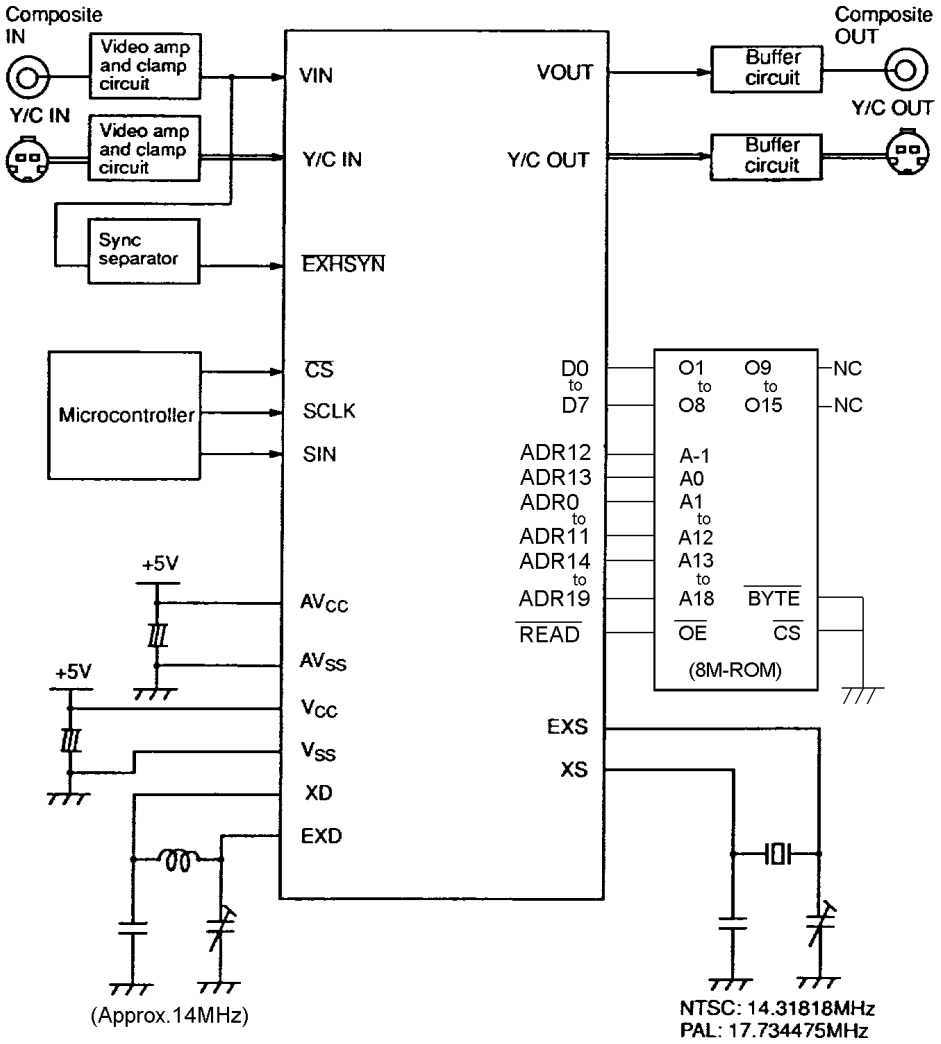


Figure 1.4-1 Example of Application Circuit

CHAPTER 2 INPUT AND OUTPUT PINS

Chapter 2 describes the functions and uses of the MB90092 input and output pins. The MB90092 is packaged in a QFP-80 containing 80 pins.

2.1 Pin Assignment

2.2 Pin Descrptions

2.1 Pin Assignment

Figure 2.1-1 shows the pin assignment of the MB90092.

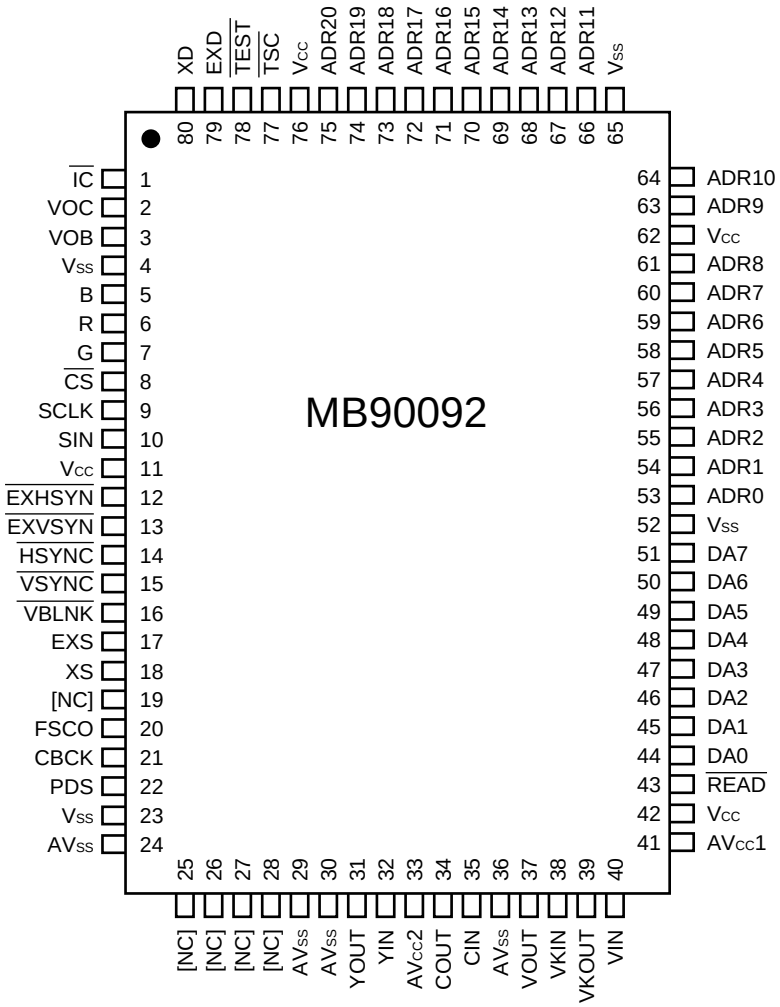


Figure 2.1-1 MB90092 Pin Assignment

2.2 Pin Descrptions

Table 2.2-1 Pin Descriptions

Pin name	Pin no.	I/O	Function
$\overline{IC}$	1	I	Internal color generation mode setting pin This pin outputs the internally generated color burst signal to the video signal output in response to Low-level input during external synchronization control operation. The pin can also be used as a reset signal input pin by Low-level input to the $\overline{TEST}$ pin. In this case, Low-level input to this pin resets the MB90092. The pin is a hysteresis input with an internal pull-up resistor.
VOC	2	O	Character interval signal output pin The output signal represents the character dot output interval.
VOB	3	O	Character/background internal signal output pin During internal synchronization control operation, the output signal represents the character, character background, line background, or screen background output interval.
B R G	5 6 7	O O O	Color signal output pins These pins output the character, character background, line background, and screen background color signals.
$\overline{CS}$	8	I	Chip select pin For serial transfer, set this pin to the Low level. This pin is also used to release a power-on reset. The pin is a hysteresis input with an internal pull-up resistor.
SCLK	9	I	Shift clock input pin for serial transfer This pin is a hysteresis input with an internal pull-up resistor.
SIN	10	I	Serial data input pin The pin is a hysteresis input with an internal pull-up resistor.
$\overline{EXHSYN}$	12	I	External horizontal sync signal input pin This pin can also serve as a composite sync signal input pin depending on the internal register setting. The pin is a hysteresis input with an internal pull-up resistor.
$\overline{EXVSYN}$	13	I	External vertical sync signal input pin Input to this pin is disabled when composite sync signal input has been selected by setting the internal register.
$\overline{HSYNC}$	14	O	Horizontal sync signal output pin This pin can also output composite sync signals depending on the internal register setting. The pin outputs the signal (FSC) resulting from dividing the 4FSC clock frequency by setting the $\overline{TEST}$ pin to the Low level.
$\overline{VSYNC}$	15	O	Vertical sync signal output pin This pin is fixed at the High level when composite sync signal output has been selected by setting the internal register. The pin outputs the dot clock oscillator signal when the $\overline{TEST}$ pin goes Low.

Table2.2-1 Pin Descriptions *(Continued)*

Pin name	Pin no.	I/O	Function
$\overline{\text{VBLNK}}$	16	O	Vertical blanking interval signal output pin This pin outputs the Low-level signal in the vertical blanking interval.
EXS XS	17 18	I O	External circuit pins for color burst clock generator Connect an external crystal oscillator (14.31818 MHz for NTSC or 17.734475 MHz for PAL) and load capacitance (C) to these pins to form a crystal oscillator circuit.
FSCO	20	O	Internal color burst clock output pin This pin controls internal color burst clock output depending on the FO bit of command 7.
CBCK	21	I	External color burst clock input pin
PDS	22	O	Pin for output of the result of color burst clock phase comparison
YOUT	31	O	Luminance signal output pin This pin outputs a signal of 2 V_{P-P} (pedestal level 1.57 V, sink chip level 1 V).
YIN	32	I	Luminance signal input pin for superimpose display This pin inputs a DC-reproduced (DC-clamped) signal of 2 V_{P-P} (pedestal level 1.57 V, sink chip level 1 V).
COUT	34	O	Saturation signal output pin This pin outputs a signal at 1.57 VDC and a color burst signal amplitude of 0.57 V_{P-P}.
CIN	35	I	Saturation signal input pin for superimpose display This pin inputs a signal at 1.57 VDC and a color burst signal amplitude of 0.57 V_{P-P}.
VOUT	37	O	Composite video signal output pin This pin outputs a signal of 2 V_{P-P} (pedestal level 1.57 V, sink chip level 1 V).
VKIN	38	I	Background level control input pin for halftone background display of external input composite video signals (input to the VIN pin and output from the VOUT pin) Halftone background display is controlled by setting the KID bit of command 5 to “1”.
VKOUT	39	O	Background level control output pin for halftone background display of external input composite video signals (input to the VIN pin and output from the VOUT pin) Halftone background display is controlled by setting the KID bit of command 5 to “1”.
VIN	40	I	Composite video signal input pin for superimpose display This pin inputs a DC-reproduced (DC-clamped) signal of 2 V_{P-P} (pedestal level 1.57 V, sink chip level 1 V).

Table2.2-1 Pin Descriptions *(Continued)*

Pin name	Pin no.	I/O	Function
$\overline{\text{READ}}$	43	O	External font memory read control pin This pin outputs the Low-level signal in the font memory read period. The pin enters the high impedance state when the $\overline{\text{TSC}}$ pin inputs a Low-level signal.
DA0 DA1 DA2 DA3 DA4 DA5 DA6 DA7	44 45 46 47 48 49 50 51	I I I I I I I I	External font memory data input pins These pins are TTL level inputs with an internal pull-up resistor.
ADR0 ADR1 ADR2 ADR3 ADR4 ADR5 ADR6 ADR7 ADR8 ADR9 ADR10 ADR11 ADR12 ADR13 ADR14 ADR15 ADR16 ADR17 ADR18 ADR19 ADR20	53 54 55 56 57 58 59 60 61 63 64 66 67 68 69 70 71 72 73 74 75	O	External font memory address output pins These pins enter the high impedance state when the $\overline{\text{TSC}}$ pin inputs a Low-level signal. ADR0 to ADR4: Raster address ADR5 — M0, SM0 ADR6 — M1, SM1 ADR7 — M2, SM2 ADR8 — M3, SM3 ADR9 — M4, SM4 ADR10 — M5, SM5 ADR11 — M6, SM6 (ADR5 to ADR11: Character code (Lower bits)) ADR12, ADR13: Data distinction bits (12,13 = 00: Left, 10: Center, 01: Right) ADR14 — M7, SM7 ADR15 — M8, SM8 ADR16 — M9, SM9 ADR17 — MA, SMA ADR18 — MB, SMB ADR19 — MC, SMC ADR20 — MD, SMD (ADR14 to ADR20: Character code (Higher bits))
$\overline{\text{TSC}}$	77	I	Tristate control input pin for external font memory control bus When this pin inputs a Low-level signal, the ADR0 to ADR20 pins and the $\overline{\text{READ}}$ pin enter the high impedance state. The pin is a hysteresis input with an internal pull-up resistor.
$\overline{\text{TEST}}$	78	I	Test signal input pin This pin usually inputs a High-level (fixed) signal.
EXD XD	79 80	I O	External circuit pins for display dot clock generator Connect these pins to external “L” and “C” to form an LC oscillator circuit.

Table2.2-1 Pin Descriptions *(Continued)*

Pin name	Pin no.	I/O	Function
[N.C]	19 25 26 27 28	— — — — —	Leave these pins unconnected.
V_{CC}	11 42 62 76	— — — —	Power-supply pins (+5 V)
V_{SS}	4 23 52 65	— — — —	Ground pins
$AV_{CC}1$	41	—	Analog power pin for composite video signals (VIN-VOUT)
$AV_{CC}2$	33	—	Analog power pin for luminance (YIN-YOUT) and chroma (CIN-COUT) signals
AV_{SS}	24 29 30 36	— — — —	Analog circuit ground pins Set these pins to the same level as the V_{SS} pin.

CHAPTER 3 DISPLAY FUNCTIONS

Chapter 3 describes the display functions of the MB90092.
The MB90092 provides two screens, called the main screen and the sub-screen, and is capable of controlling the display priority for each line. It can also display the screen background color that will be used as the background color of the main screen and sub-screen.

3.1 Screen Configuration
3.2 Character Configuration
3.3 Character Display Functions
3.4 Graphic Character Display Functions

3.1 Screen Configuration

The MB90092 provides two screens: the main screen on which data can be set for each character and the sub-screen on which data can be set for each line (or for the entire screen). The overall background can be represented using the screen background color.

Figure 3.1-1 shows an example of main screen and sub-screen merged.

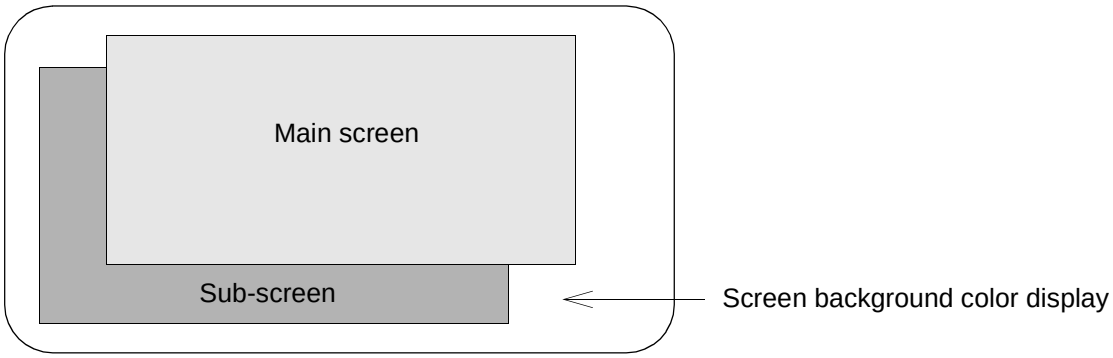


Figure 3.1-1 Example of Main Screen and Sub-Screen Merged

The MB90092 can provide two screens, called the main screen and the sub-screen, either independently or overlayed one on top of the other.

The main screen consists of 24 characters by 12 lines and allows data to be set for each character. The sub-screen consists of 24 characters by 12 lines or up to 32 characters by 16 lines. Data can be set either for each line in the former configuration or collectively for the entire screen in the latter configuration.

The characters supported by the MB90092 are the normal characters made up of 24 by 32 dots and the 8 × 32-dot graphic characters that can be displayed in any of eight different colors in character units.

If filled with only graphic characters, the main screen is 192 (horizontal) × 384 (vertical) dots. In the same case, the sub-screen is 192 (horizontal) × 384 (vertical) dots, or 256 (horizontal) × 512 (vertical) dots. (The actual display screen depends on the dot clock frequency in the horizontal direction and on the number of rasters of the television system in the vertical direction.) The MB90092 uses RAM as font memory, enabling free graphics display.

The MB90092 can use up to 16384 types of characters including normal and graphic characters in total. It can control up to 16M bits of external font memory.

For output of video signals, the MB90092 has the composite video signal, Y/C-separated video signal, and RGB digital output pins. The MB90092 also has video signal input pins, allowing superimpose display over either composite video signals and Y/C-separated video signals.

3.1.1 Main Screen Configuration

The main screen displays up to 24 characters by 12 lines. It offers a choice of two display modes: the normal mode for displaying only normal characters and the extended graphics mode in which both normal and graphic characters can be displayed, selectable character by character.

■ Main Screen Features

- Normal mode and extended graphics mode
- Screen configuration: 24 characters × 12 lines (data settable for each character)
- Character sizes: Five different types (selectable for each line)

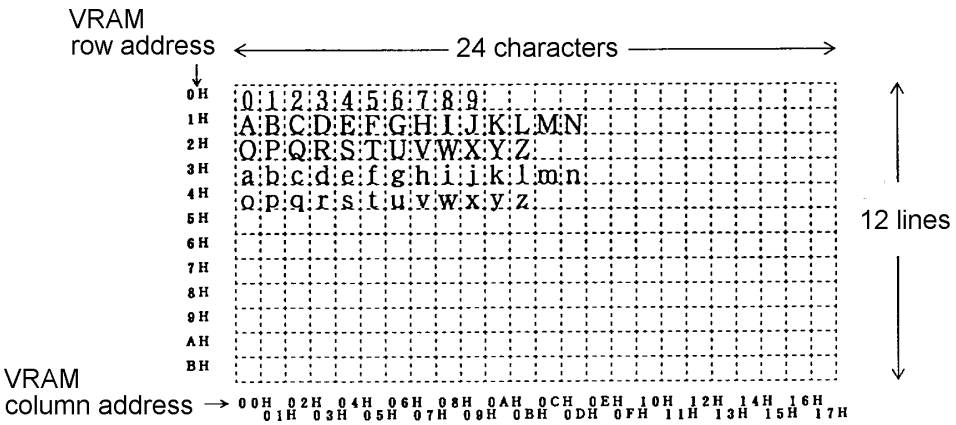
- Line spacing: 0 to 15 rasters
- Display position control (Vertical: In raster units, Horizontal: In 1/3-character units)
- Setting display priority over the sub-screen (for each line)
- Output control (for each line)

(1) Display Screen Configuration in Standard Character Size

The MB90092 can display up to 24 characters x 12 lines (= 288 characters) in standard character size. The number of characters that can be displayed on a screen may be fewer than that if displayed in an enlarged size or depending on the vertical or horizontal display start positions.

Figure 3.1-2 shows a display screen configuration in standard character size.

1) Display configuration in VRAM


VRAM
row address
24 characters
0H 0 1 2 3 4 5 6 7 8 9
1H A B C D E F G H I J K L M N
2H O P Q R S T U V W X Y Z
3H a b c d e f g h i j k l m n
4H o p q r s t u v w x y z
5H
6H
7H
8H
9H
AH
BH
12 lines
VRAM
column address
00H 02H 04H 06H 08H 0AH 0CH 0EH 10H 12H 14H 16H
01H 03H 05H 07H 09H 0BH 0DH 0FH 11H 13H 15H 17H

2) Display configuration on screen

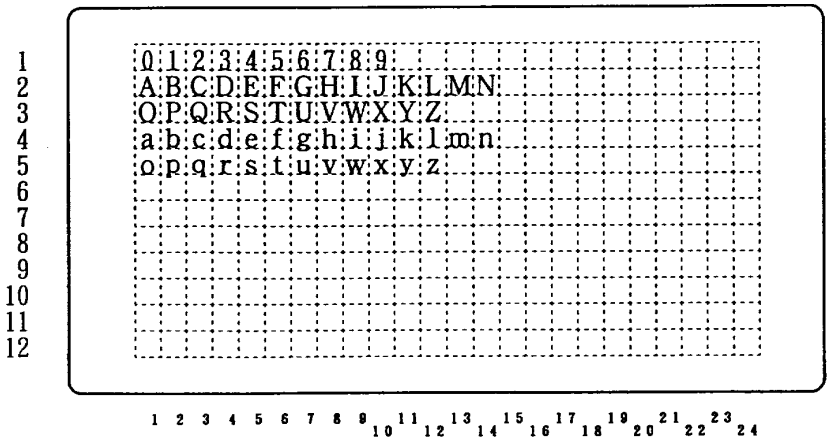


Figure 3.1-2 Display Configuration on Screen

(2) Display Screen Configuration When Enlarged Characters are Used

Five character sizes (standard, double width, double height, double width x double height, and quadruple width x double height) can be set for each line.

Set the character size in the G2 to G0 bits of the main screen line control (Command 6) and main screen line control 2 (Command 2-3).

When vertically enlarged characters are displayed, there are two different ways of displaying them. The selection is made with the GYZ bit (enlarged line display control) of screen control 2 (Command 5).

- If GYZ = 0 in Command 5:
  When characters are vertically enlarged, any lines following the enlarged line are moved down in sequence.
- If GYZ = 1 in Command 5:
  When characters are vertically enlarged, the line immediately following the enlarged line is not displayed, and any subsequent lines are displayed where they originally were (in the same positions as if no enlarged line existed).

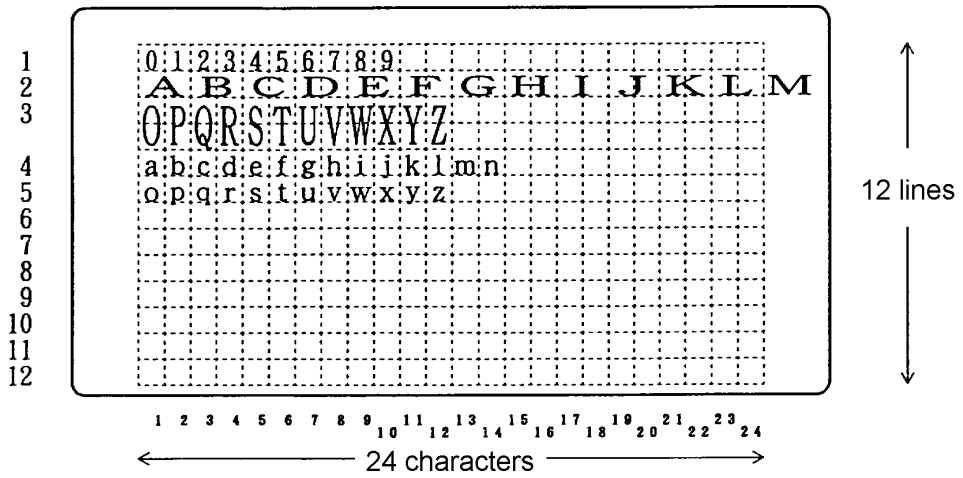
For example, if the second line is made double height (or double width x double height, or quadruple width x double height), the third line is no longer visible (not displayed) and the fourth and later lines remain where they originally were.

Additionally, the vertical enlargement specification made for a higher line overrides any such specification for subsequent lines.

For example, if the third line is made double height and then the second line is made double height, the third line is hidden by the vertically enlarged display of the second line. Additionally, the fourth line, previously hidden by the third line, becomes visible.

Figure 3.1-3 shows the display screen configuration when enlarged characters are used.

1) If GYZ = 0 in Command 5:


0 1 2 3 4 5 6 7 8 9
A B C D E F G H I J K L M
N O P Q R S T U V W X Y Z
a b c d e f g h i j k l m n
o p q r s t u v w x y z
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
24 characters
12 lines

2) If GYZ = 1 in Command 5:

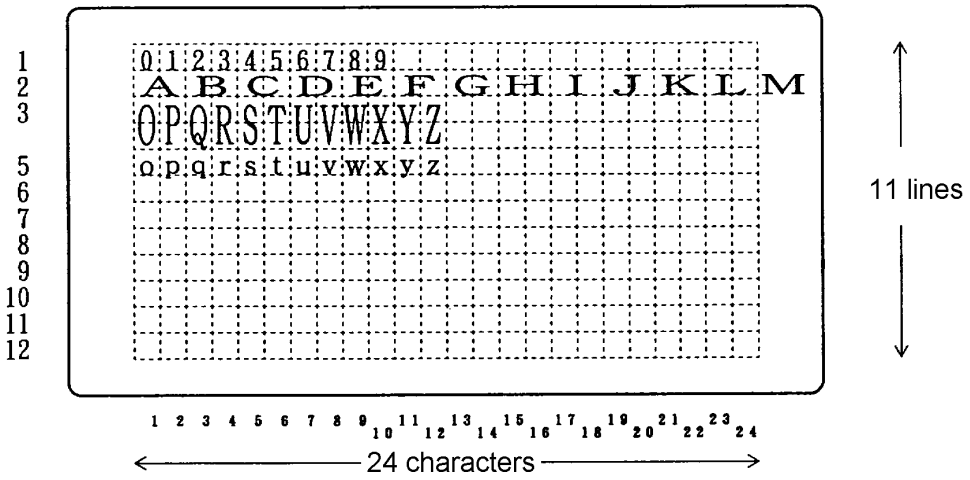


Figure 3.1-3 Display Screen Configuration When Enlarged Characters Are Used

(3) Display Screen Configuration When Line Spacing is Set

The line spacing can be set to a value from 0 to 15 rasters (in steps of one raster).

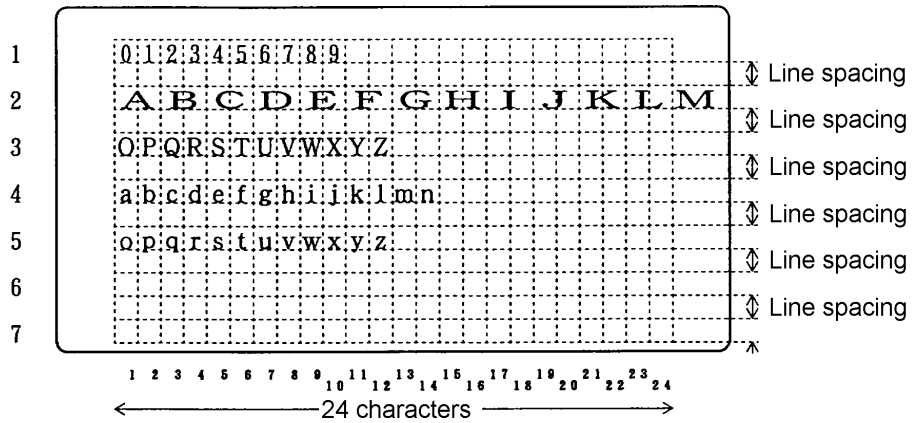
Set screen control 2 (Command 5) to one of W3 through W0 to simultaneously control all the line spacings on screen.

If enlarged characters are used, the line spacing, depending on the GYZ bit of screen control 2 (Command 5), is as follows:

- If GYZ = 0:
  All the line spacings are as indicated by the set value.
- If GYZ = 1:
  Only the line spacing of the line following the vertically enlarged line is twice the amount indicated by the set value.

Figure 3.1-4 shows the display screen configuration when line spacing is set.

1) If no vertically enlarged line exists:


1
2
3
4
5
6
7
0 1 2 3 4 5 6 7 8 9
A B C D E F G H I J K L M
O P Q R S T U V W X Y Z
a b c d e f g h i j k l m n
o p q r s t u v w x y z
Line spacing
Line spacing
Line spacing
Line spacing
Line spacing
Line spacing
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
24 characters

2) A vertically enlarged line exists and GXY = 0 in Command 5:

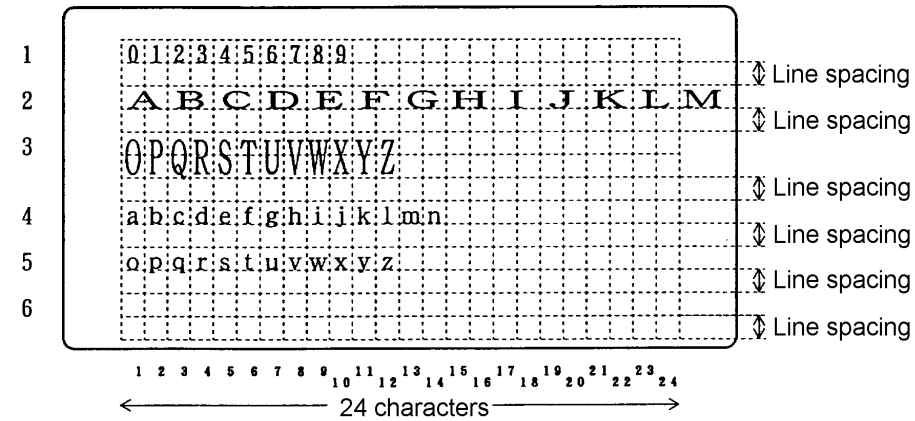

1
2
3
4
5
6
0 1 2 3 4 5 6 7 8 9
A B C D E F G H I J K L M
O P Q R S T U V W X Y Z
a b c d e f g h i j k l m n
o p q r s t u v w x y z
Line spacing
Line spacing
Line spacing
Line spacing
Line spacing
Line spacing
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
24 characters

Figure 3.1-4 Display Screen Configuration When Line Spacing is Set

3) A vertically enlarged line exists and GXY = 1 in Command 5:

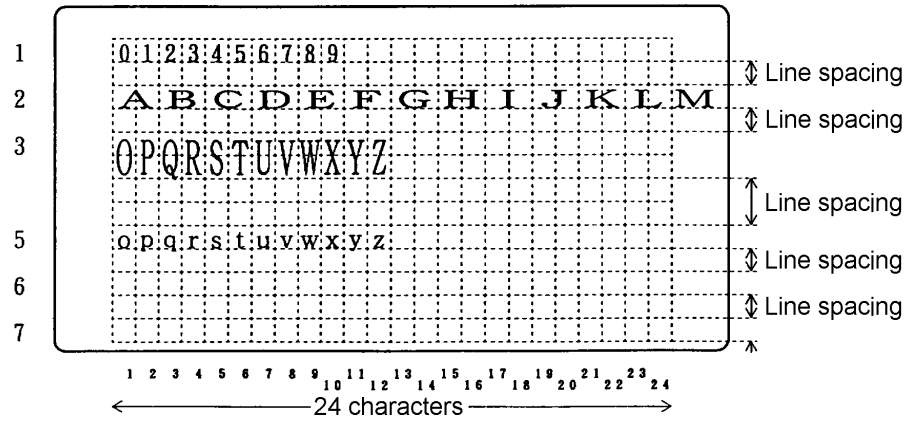

1
2
3
5
6
7
0 1 2 3 4 5 6 7 8 9
A B C D E F G H I J K L M
O P Q R S T U V W X Y Z
o p q r s t u v w x y z
Line spacing
Line spacing
Line spacing
Line spacing
Line spacing
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
24 characters

Figure 3.1-4 Display Screen Configuration When Line Spacing is Set *(Continued)*

(4) Screen Display Position

The main screen display position can be set in raster units in the vertical direction, and in 1/3 character units in the horizontal direction. The setting range is 0 to 63 rasters for the vertical direction, and 0 to 21 characters for the horizontal direction.

To set the screen display position, specify the position of the character dot at the upper left corner of the screen.

Set the vertical display position in Y5 to Y0 in the main screen vertical position control (Command 7), and the horizontal display position in X5 to X0 in the main screen horizontal position control (Command 8).

Based on the values set, the display position shall be as follows:

- Main screen vertical display position
  = $Y5\times2^5+Y4\times2^4+Y3\times2^3+Y2\times2^2+Y1\times2^1+Y0\times2^0+1$ [H]
  (Number of H's from the rise of $\overline{\text{VSYNC}}$)
- Main screen horizontal display position
  = $(X5\times2^5+X4\times2^4+X3\times2^3+X2\times2^2+X1\times2^1+X0\times2^0)\times8+88$[Dot clock]
  (Number of dot clocks from the rise of $\overline{\text{HSYNC}}$)

Figure 3.1-5 shows the main screen display position.

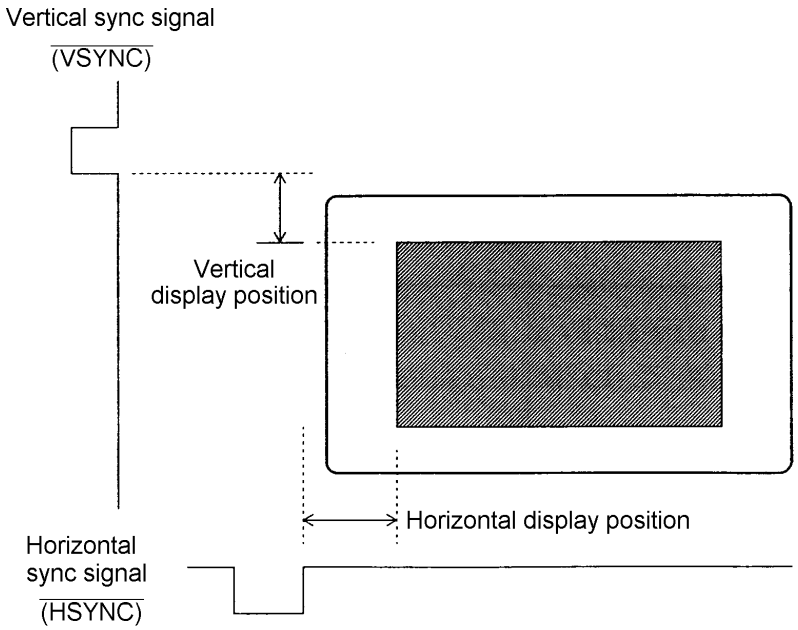


Figure 3.1-5 Main Screen Display Position

3.1.2 Sub-screen Configuration

The sub-screen offers a choice of two screen modes: the normal screen mode on which data can be set for each line and the full-screen moe A or B for full-screen display.

In the normal screen mode, the sub-screen displays up to 32 characters by 12 lines. The number of horizontal characters can range from 1 to 32 (1, 2, 4, 8, 16, 24, or 32 characters) depends on the SG2-SG0 setting of command 11 (sub-screen control).

Setting the code for the character to be displayed at the left end of each line allows a string of continuous characters of the same character code (address) to be displayed as many as the specified number of horizontal characters.

The full-screen mode enables display using the entire screen (screen display area: 32 characters × 16 lines). Setting the code for the character to be displayed at the upper left corner of the screen allows a string of continuous characters of the same character code to be displayed on the entire screen. Full-screen mode A or B is selected depending on the display area setting.

■ Sub-screen Features

- Normal screen mode/full-screen mode A/full-screen mode B
- Display position control (Vertical: In raster units, Horizontal: In 2-dot units)
- Setting display priority over the main screen (for each line on the main screen)
- Output control (for each line)

(1) Display Screen Configuration in Normal Screen Mode

The sub-screen configuration is determined according to the settings in the sub-screen configuration control (SG2 to 0) of the sub-screen control (Command 11).

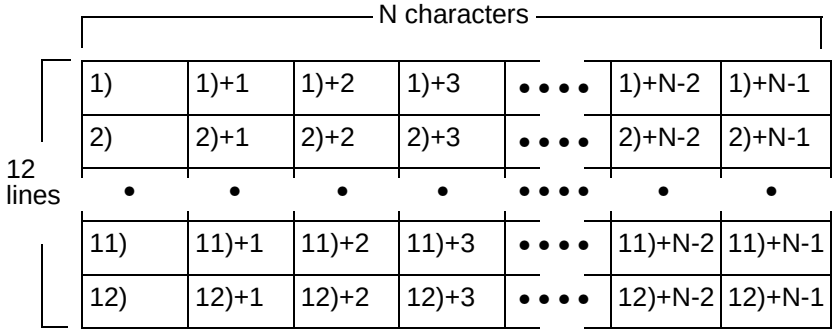
SG2	SG1	SG0	Sub-screen configuration
0	0	0	1 character x 12 lines
0	0	1	2 characters x 12 lines
0	1	0	4 characters x 12 lines
0	1	1	8 characters x 12 lines
1	0	0	16 characters x 12 lines
1	0	1	24 characters x 12 lines
1	1	0	32 characters x 12 lines
1	1	1	Full screen display mode (32 characters x 16 lines)

Set the character code to be displayed at the beginning (left end) of each line to display as many characters of the repeated character code (address) as there are number of characters in the horizontal direction.

Set the start character code of display lines (upper left corner of the screen) in the sub-screen line start code (SMD to SM0) of the sub-screen line control (Commands 1-2 and 2-2).

Figure 3.1-6 shows the screen configuration in the normal screen mode.

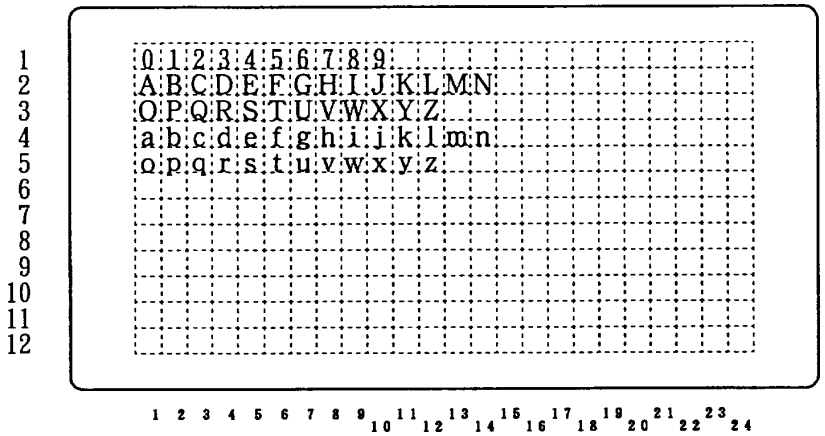
1) Screen configuration in the normal screen mode



- 1) through 12) are any character codes (addresses).
- N is the number of characters in the horizontal direction in the sub-screen configuration according to the settings in SG2 to 0.

Figure 3.1-6 Screen Configuration in the Normal Screen Mode

2) Sub-screen configuration example 1: If SG 2 to 0 = (1, 0, 1)


0 1 2 3 4 5 6 7 8 9
A B C D E F G H I J K L M N
O P Q R S T U V W X Y Z
a b c d e f g h i j k l m n
o p q r s t u v w x y z
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

3) Sub-screen configuration example 2: If SG 2 to 0 = (0, 1, 1)

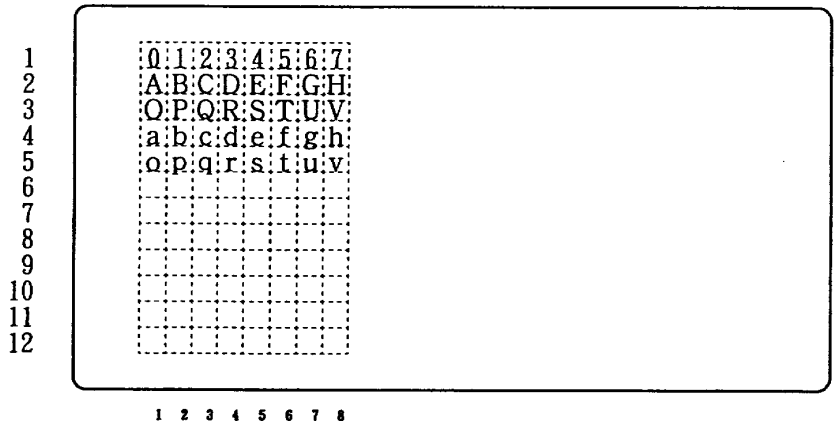


Figure 3.1-6 Screen Configuration in the Normal Screen Mode *(Continued)*

(2) Display Screen Configuration in Full Screen Mode A

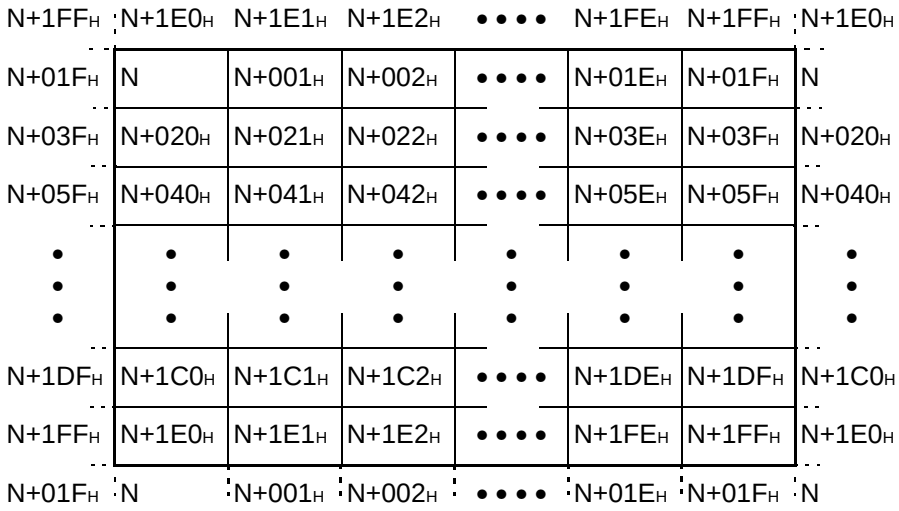
In full screen mode A, 32 virtual screens of 32 characters by 16 lines are provided. For any of these screens, you can extract and display any rectangular area (32 characters by 16 lines) in the entire screen. To set the display screen, specify the character code (address) of the upper left corner of the screen.

Full screen mode A is selected if the sub-screen configuration control (SG 2 to 0) = (1, 1, 1) in the sub-screen control (Command 11) and the sub-screen full screen mode control (SGA) = (0) in the sub-screen vertical position control (Command 12).

Set the start character code of display lines (upper left corner of the screen) in the sub-screen line start code (SMD to SM0) of the sub-screen line control (Commands 1-2 and 2-2).

1) Virtual screen configuration in full screen mode A: 32 characters by 16 lines (by 32 screens)

Figure 3.1-7 shows the virtual screen configuration in full screen mode A.


N+1FFH N+1E0H N+1E1H N+1E2H • • • • N+1FEH N+1FFH N+1E0H
N+01FH N N+001H N+002H • • • • N+01EH N+01FH N
N+03FH N+020H N+021H N+022H • • • • N+03EH N+03FH N+020H
N+05FH N+040H N+041H N+042H • • • • N+05EH N+05FH N+040H
N+1DFH N+1C0H N+1C1H N+1C2H • • • • N+1DEH N+1DFH N+1C0H
N+1FFH N+1E0H N+1E1H N+1E2H • • • • N+1FEH N+1FFH N+1E0H
N+01FH N N+001H N+002H • • • • N+01EH N+01FH N

- N = Xn00H [Character code (address)]
  X = (0H, 1H, 2H, 3H)
  n = (0H, 2H, 4H, 6H, 8H, AH, CH, EH)
- Virtual screens are connected with each other from the left to the right sides and from the top to the bottom.
- Specify the character code (address) of the upper left corner of the display screen to display any rectangular area (max. 32 characters by 16 lines). (The display screen size depends on the TV system and the dot clock frequency. In general, not all of the area defined by 32 characters by 16 lines can be displayed.)

Figure 3.1-7 Virtual Screen Configuration in Full Screen Mode A

2) Screen configuration in full screen mode A

Figure 3.1-8 shows an example of the screen configuration in full screen mode A.

If the start character code of display screen (upper left corner of the screen) is set to 0042_H, the shaded part shown in this figure is displayed. (The actual display screen size depends on the display period of the specific television system and the dot clock frequency. In general, not all of the 32 characters can be displayed. The figure below shows 27 characters by 12 lines, which varies according to conditions.)

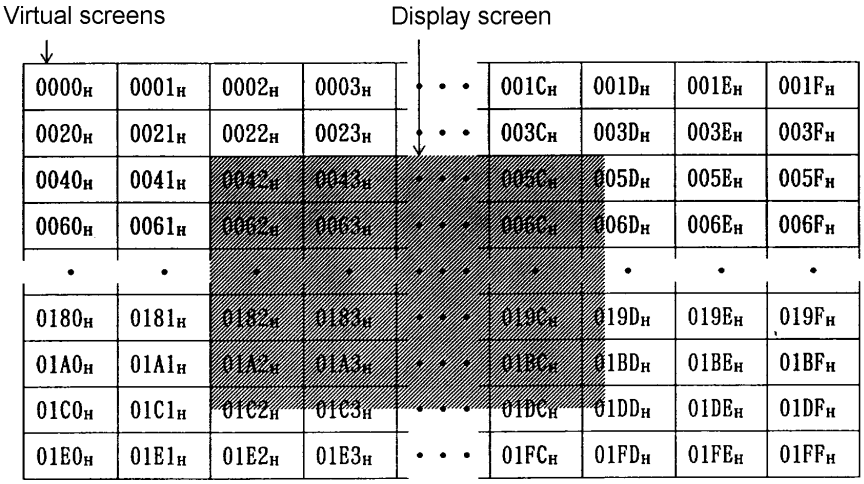


Figure 3.1-8 Example of the Screen Configuration in Full Screen Mode A

3) Example of the screen display in full screen mode A

Figure 3.1-9 shows an example of the screen display in full screen mode A.

Part of the virtual screens can be extracted and displayed.

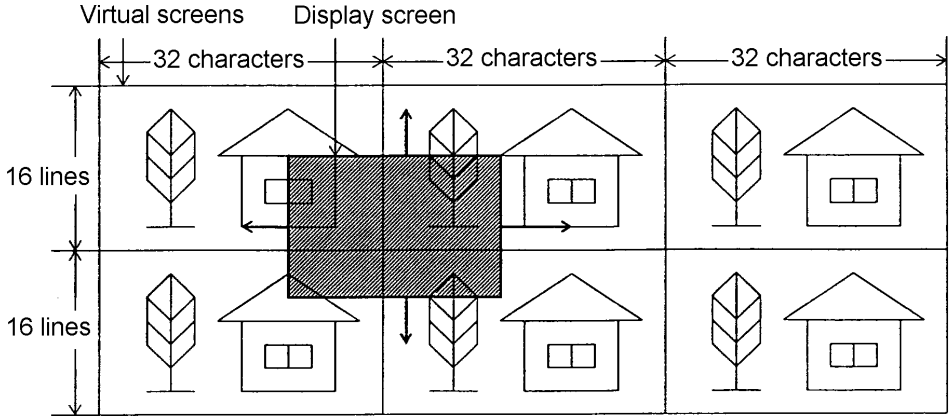


Figure 3.1-9 Example of the Screen Display in Full Screen Mode A

(3) Display Screen Configuration in Full Screen Mode B

In full screen mode B, virtual screens of 512 characters by 32 lines are provided. In any of these screens, you can extract and display any rectangular area (32 characters by 16 lines) on the entire TV screen. (The actual display screen size depends on the display period of the specific television system and the dot clock frequency. In general, not all of the area defined by 32 characters by 16 lines can be displayed.)

To set the display screen, specify the character code (address) of the upper left corner of the screen.

Full screen mode B is selected if the sub-screen configuration control (SG 2 to 0) = (1, 1, 1) in the sub-screen control (Command 11) and the sub-screen full screen mode control (SGA) = (1) in the sub-screen vertical position control (Command 12).

Set the start character code of display lines (upper left corner of the screen) in the sub-screen line start code (SMD to SM0) of the sub-screen line control (Commands 1-1 and 2-2). (A line control specification made for lines after the first is invalid.)

1) Virtual screen configuration in full screen mode B: 512 characters by 32 lines

Figure 3.1-10 shows the virtual screen configuration in full screen mode B.

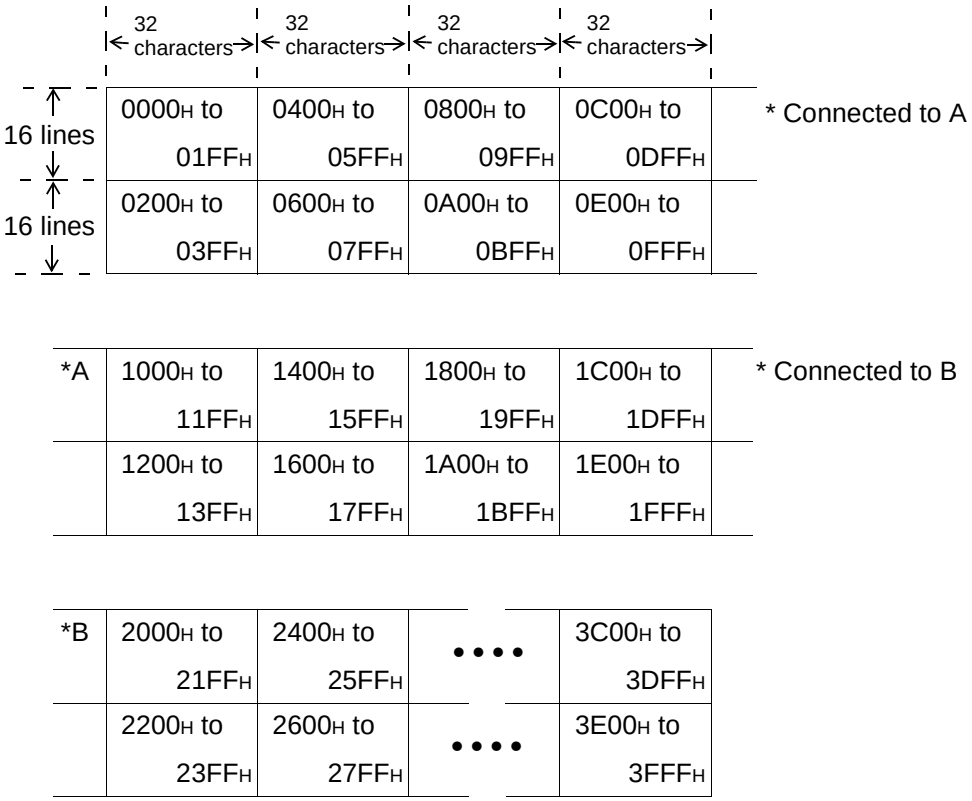
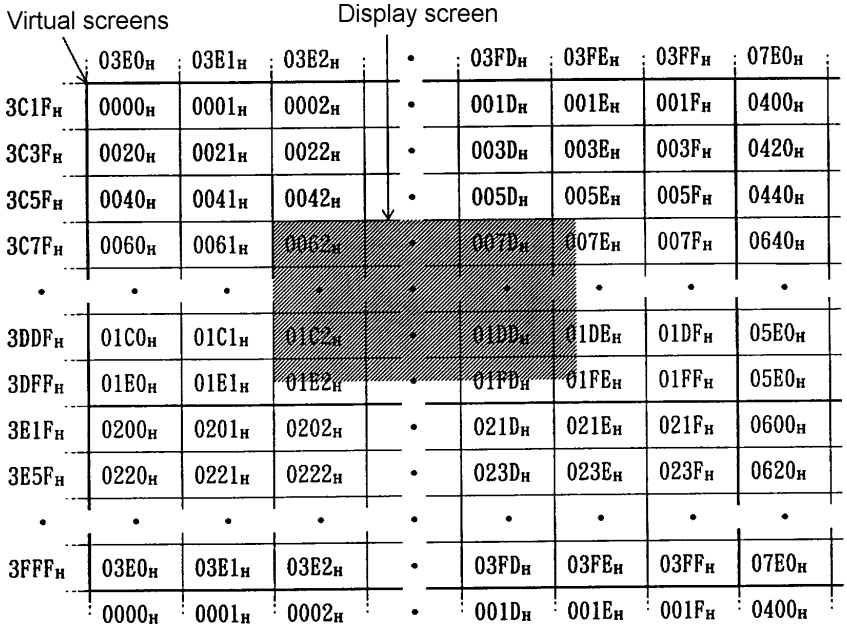


Figure 3.1-10 Virtual Screen Configuration in Full Screen Mode B

2) Screen configuration in full screen mode B

Figure 3.1-11 shows an example of the screen configuration in full screen mode B.

If the start character code of the display screen (upper left corner of the screen) is set to 0062_H, the shaded part shown in this figure is displayed. (The actual display screen size depends on the display period of the specific television system and the dot clock frequency. In general, not all of the area defined by 32 characters by 16 lines can be displayed. The figure below shows 28 characters by 12 lines, which varies according to the conditions.)



- Specify the character code (address) of the upper left corner of the display screen to display any rectangular area.
- Virtual screens are connected with each other from the left to the rig sides, and from the top to the bottom.

Figure 3.1-11 Example of the Screen Configuration in Full Screen Mode B

3) Example of the screen display in full screen mode B

Figure 3.1-12 shows an example of the screen display in full screen mode B.

Some of the virtual screens can be extracted and displayed as shown below.

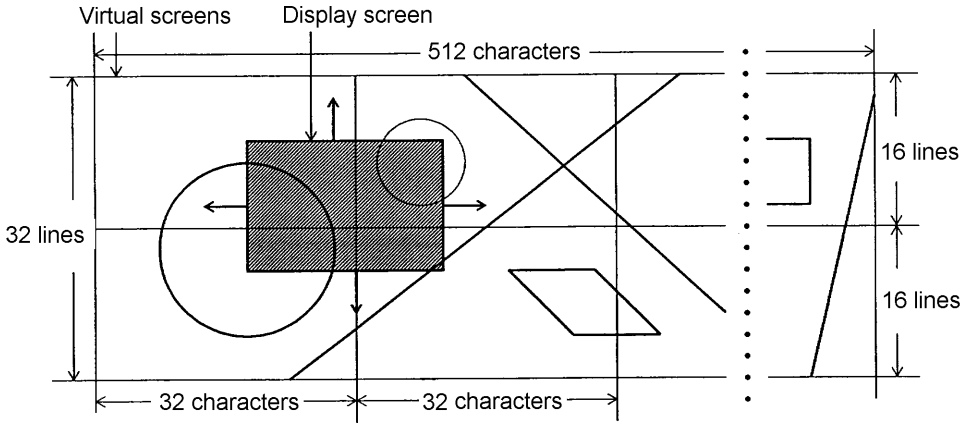


Figure 3.1-12 Example of the Screen Display in Full Screen Mode B

(4) Sub-screen Display Position

The sub-screen display position can be set in raster units in the vertical direction, and in 2-dot units in the horizontal direction. The setting range is 0 to 510 rasters for the vertical direction, and 0 to 1022 characters for the horizontal direction. (However, if the position is set outside the display period of the television signals, the screen is not displayed.)

To set the screen display position, specify the position of the character dot at the upper left corner of the screen.

Set the vertical display position in SY7 to SY0 in the sub-screen vertical position control (Command 12), and the horizontal display position in SX8 to SX0 in the sub-screen horizontal position control (Command 13).

Based on the values set, the display position shall be as follows:

- Sub-screen vertical display position
  = $SY7\times2^7 + SY6\times2^6 + SY5\times2^5 + SY4\times2^4 + SY3\times2^3 + SY2\times2^2 + SY1\times2^1 + SY0\times2^0 + 1$ [H]
  (Number of H's from the rise of $\overline{\text{VSYNC}}$)
- Sub-screen horizontal display position
  = $(SX8\times2^8 + SX7\times2^7 + SX6\times2^6 + SX5\times2^5 + SX4\times2^4 + SX3\times2^3 + SX2\times2^2 + SX1\times2^1 + SX0\times2^0)\times2 + 72$ [Dot clock]
  (Number of dot clocks from the rise of $\overline{\text{HSYNC}}$)

Figure 3.1-13 shows the sub-screen display position.

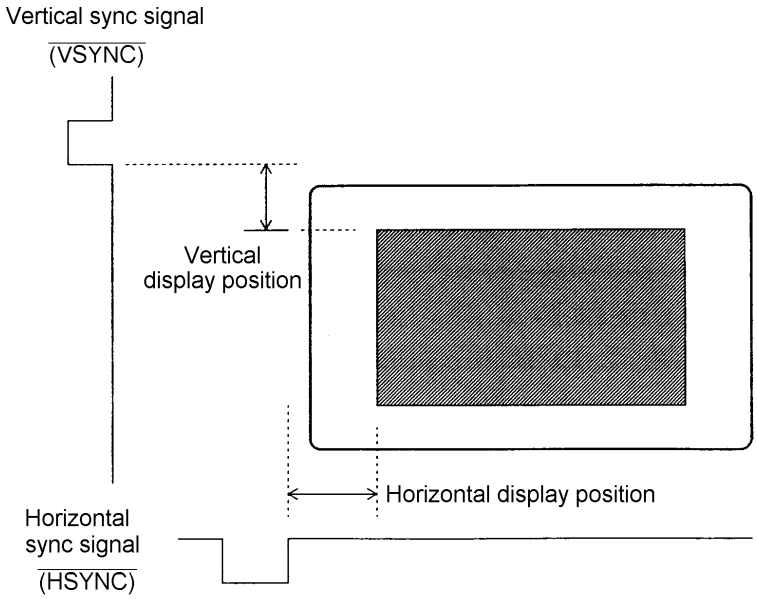


Figure 3.1-13 Sub-screen Display Position

3.2 Character Configuration

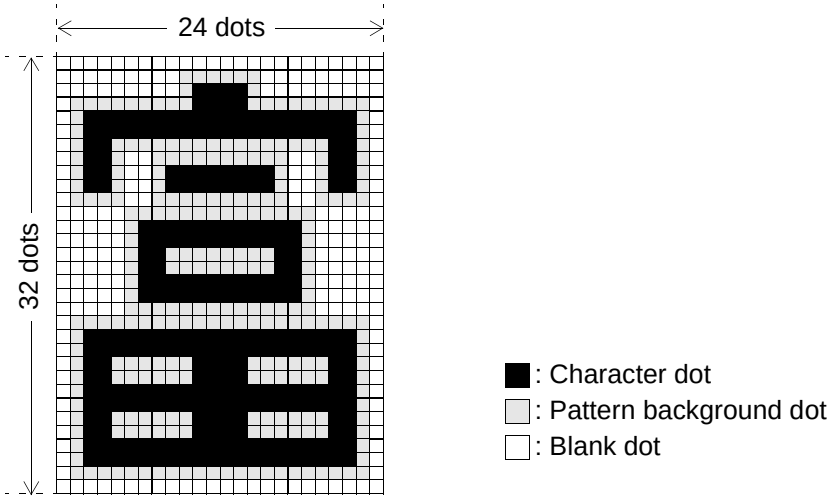
3.2.1 Normal and Graphic Characters

The MB90092 can display two types of characters: normal characters and graphic characters.

Normal characters each consist of 24 horizontal dots × 32 vertical dots. Graphic characters each consists of 8 horizontal dots × 32 vertical dots. The normal and graphic characters are the same in size (3 horizontal dots for normal characters equal to one horizontal dot for graphic characters). The display color can be set for each dot of only graphic characters.

Figure 3.2-1 shows character configuration examples.

(1) Normal character configuration example:



(2) Graphic character configuration example:

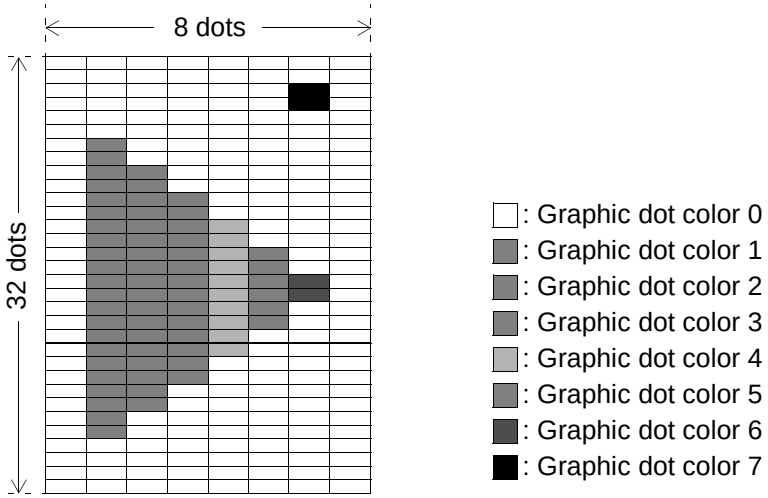

8 dots
32 dots
: Graphic dot color 0
: Graphic dot color 1
: Graphic dot color 2
: Graphic dot color 3
: Graphic dot color 4
: Graphic dot color 5
: Graphic dot color 6
: Graphic dot color 7

Figure 3.2-1 Character Configuration Examples

3.2.2 Character Sizes

Five different character sizes are available: standard, double width, double height, double width × double height, and double height × quadruple width. The character size can be specified for only the main screen. The sub-screen can display only the standard size of characters.

Figure 3.2-2 shows character configuration examples of each character size.

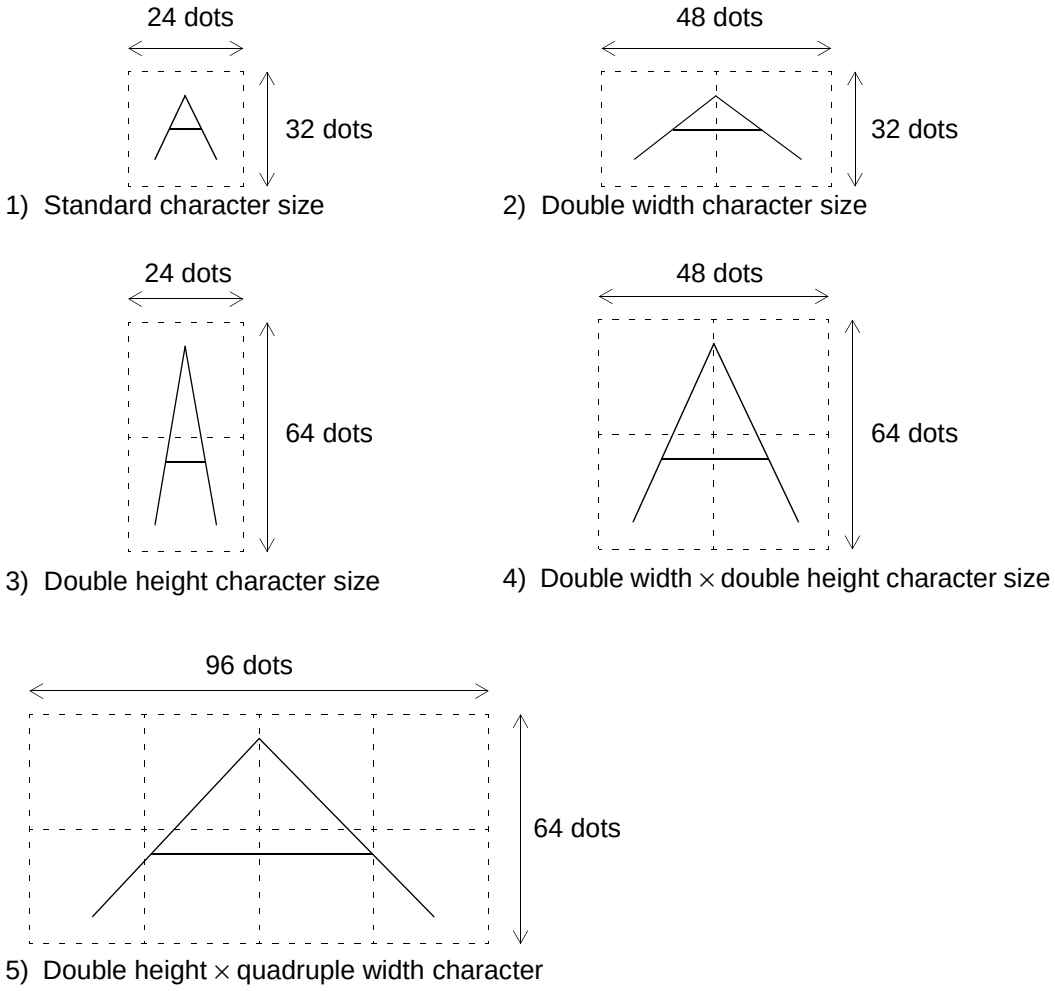


Figure 3.2-2 Zoom-in Display Function

Note: The number of horizontal dots is based on the normal character dot as a unit dot.
One dot for graphic characters is equivalent to three horizontal dots for normal characters.

3.2.3 Zoom-in Display Function

The zoom-in display function displays each character on the main screen using 48 vertical dots by vertically doubling only the upper 24 dots of font data which is 32 dots in height.

Set 1 in the ZM bit of screen control 1 (Command 4) to enable the zoom-in function. However, the zoom-in function is not enabled in kanji font mode (RM0 = 1 or RM0 = 1 in Command 9).

Characters enlarged by the zoom-in function can be further enlarged by separately specifying the desired character size.

Figure 3.2-3 shows an example of the zoom-in display of one character.

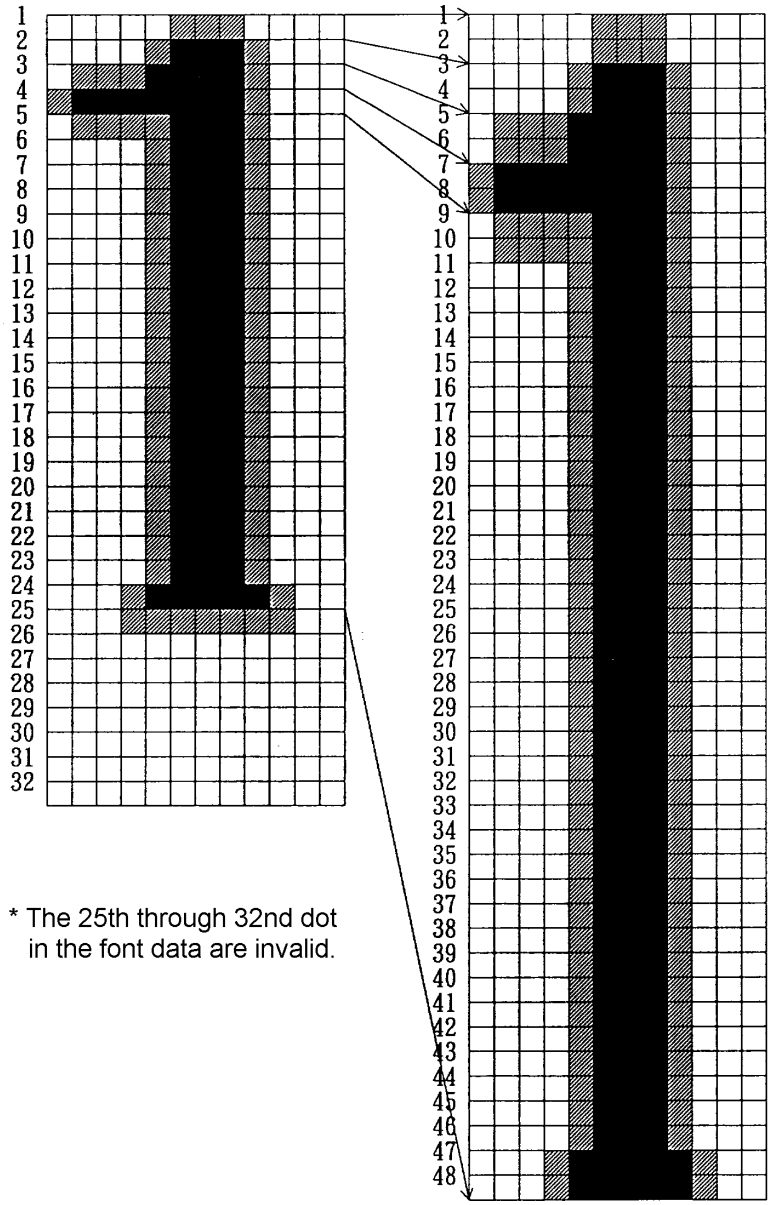


Figure 3.2-3 Example of Zoom-in Display (One Character)

If characters in an ordinary kanji font of 24 by 24 dots (e.g., a kanji ROM font) are displayed, an 8-dot blank area appears below the characters as shown in (1) of Figure 3.2-4. If the zoom-in display is used, the spacing between characters (between lines) can be reduced, as shown in (2) of Figure 3.2-4. (The line spacing may be separately set to any value.)

Note: Since characters are elongated vertically to twice their height, lines below may disappear from the display screen. Normally, up to about eight lines can be displayed.

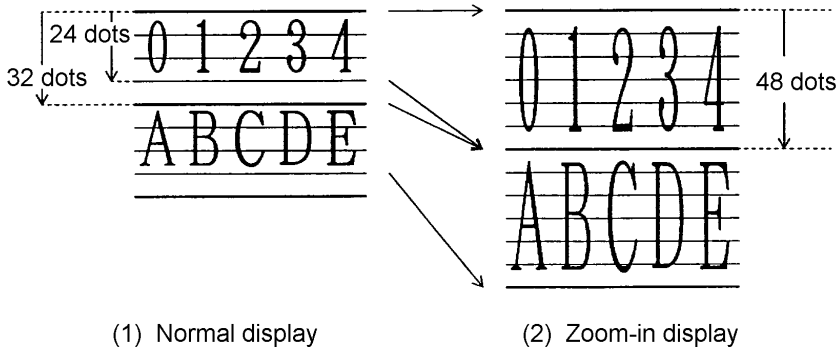


Figure 3.2-4 Example of Zoom-in Display (Multiple Characters)

3.3 Character Display Functions

The character display functions available in the normal character display mode of the MB90092 include: “pattern background display” for displaying arbitrarily shaped patterns around character dots, “solid-fill background display” for filling the entire character cell made up of 24 × 32 dots with a background color, “shaded background display” for adding 3D shading to the perimeter of the solid-fill background, and “blink display” for blinking.

The MB90092 also provides “kanji font display” functions for framing and boldfacing of kanji fonts (such as the kanji ROM font) for easier viewing.

3.3.1 Pattern Background Display

A pattern background can be displayed for normal characters (except for a specified kanji font) on the main screen and the sub-screen.

The pattern background shall be set at the time the font is created. In addition to the character dots, a font of any shape can be displayed. Alternatively, the pattern background can be set as framing dots around the character dots. If the MB90092 font editor is used to create a font, the font's pattern background is automatically created.

There are four types of pattern backgrounds: pattern background 0, pattern background 1, pattern background 2, and pattern background 3. The pattern background is selected according to the settings in the P2 and P0 bits of screen control 1 (Command 4). The settings are common to the main screen and the sub-screen.

Table 3.3-1 shows the pattern background mode.

Figure 3.3-1 shows an example of pattern background configuration

Table 3.3-1 Pattern Background Mode

P2	P0	Pattern background mode
0	0	Pattern background 1
0	1	Pattern background 0
1	0	Pattern background 2
1	1	Pattern background 3

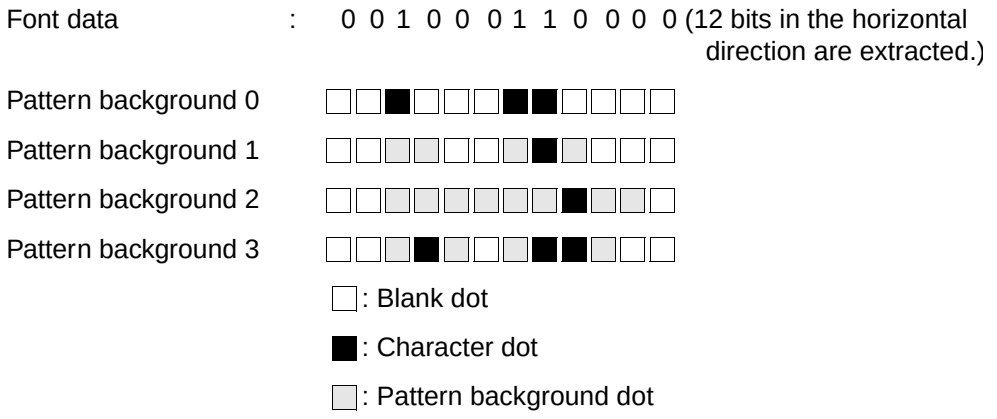

Font data : 0 0 1 0 0 0 1 1 0 0 0 0 (12 bits in the horizontal direction are extracted.)
Pattern background 0
Pattern background 1
Pattern background 2
Pattern background 3
: Blank dot
: Character dot
: Pattern background dot

Figure 3.3-1 Example of Pattern Background Configuration

Note: This example applies for SF1 = 0 in Command 9.

The pattern background color indicates the character background color that is set for each character in normal mode. In extended graphic mode, it indicates the line background color that is set for each line.

A pattern background on the main screen is displayed unless the solid-fill background is specified. The pattern background of the sprite screen is always displayed.

In normal mode, the pattern background color (character background color) is set in the BG, BR, and BB bits of Command 1-1 (main screen character control 1). In extended graphic mode, the pattern background color (line background color) is set in the KG, KR, and KB bits of Command 2-3 (main screen line control 2). In normal mode, the specification of color or monochrome for the pattern background color is set in the BC bit (specification for the entire screen) of Command 10 (color control). In extended graphic mode, it is set in the KC bit (specification for each line) of Command 2-3 (main screen line control 2).

The pattern background is displayed if AT = 0 or AT = 1 in Command 1-1 (main screen character control 1) and BK = 0 in Command 10 (color control). The AT bit can be set for each character.

Figure 3.3-2 shows an example of pattern background display.

Note: If a character dot is set as the rightmost dot (24th dot) or the dot before the rightmost one (23rd dot) in the horizontal 24-dot character area, the pattern background dot may leave the character area and be displayed in the adjacent character area on the right. However, the pattern background never extends beyond the right edge of the character display screen area (24th dot of the 24th character).

(1) Pattern background 0 display (Font data display)

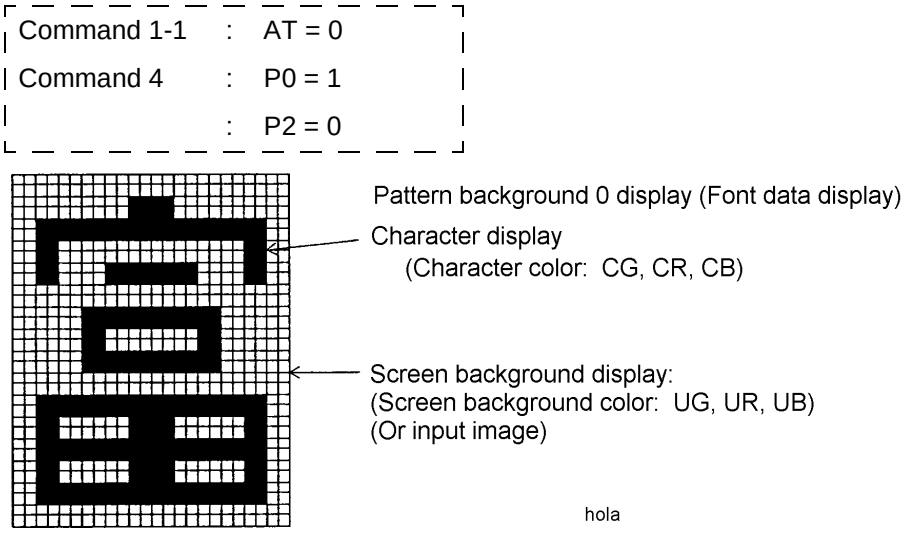
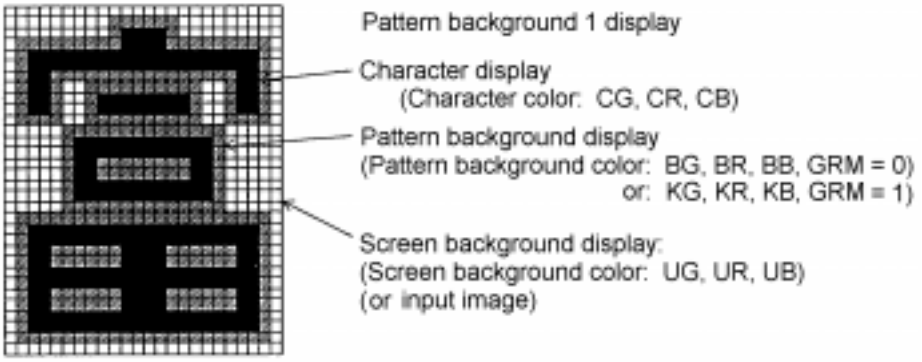

Command 1-1 : AT = 0
Command 4 : P0 = 1
: P2 = 0
Pattern background 0 display (Font data display)
Character display
(Character color: CG, CR, CB)
Screen background display:
(Screen background color: UG, UR, UB)
(Or input image)
hola

Figure 3.3-2 Example of Pattern Background Display

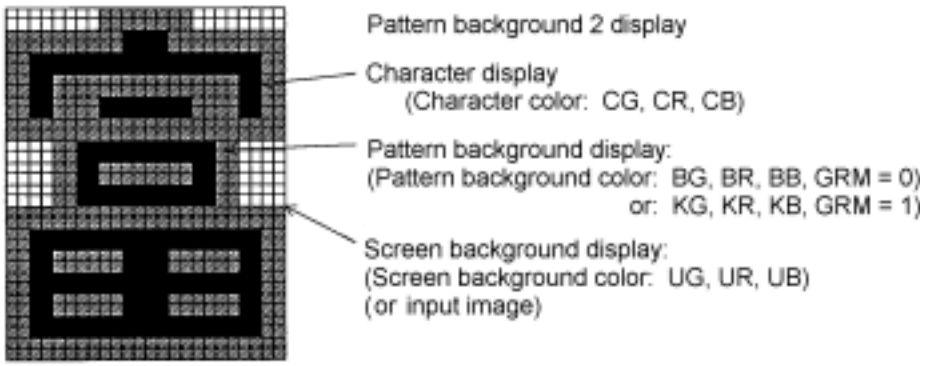
(2) Pattern background 1 display

Command 1-1	:	AT = 0
Command 4	:	P0 = 0
	:	P2 = 0


Pattern background 1 display
Character display
(Character color: CG, CR, CB)
Pattern background display
(Pattern background color: BG, BR, BB, GRM = 0)
or: KG, KR, KB, GRM = 1)
Screen background display:
(Screen background color: UG, UR, UB)
(or input image)

(3) Pattern background 2 display

Command 1-1	:	AT = 0
Command 4	:	P0 = 0
	:	P2 = 1


Pattern background 2 display
Character display
(Character color: CG, CR, CB)
Pattern background display:
(Pattern background color: BG, BR, BB, GRM = 0)
or: KG, KR, KB, GRM = 1)
Screen background display:
(Screen background color: UG, UR, UB)
(or input image)

(4) Pattern background 3 display (Same display mode as horizontal framing 1 of the kanji font pattern background)

Command 1-1	:	AT = 0
Command 4	:	P0 = 1
	:	P2 = 1

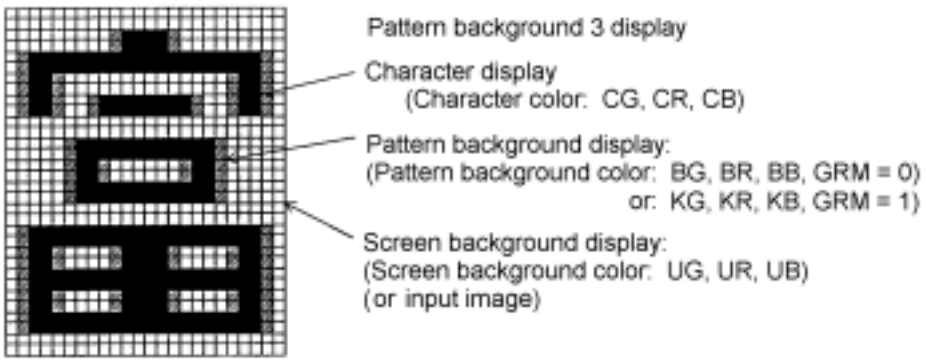

Pattern background 3 display
Character display
(Character color: CG, CR, CB)
Pattern background display:
(Pattern background color: BG, BR, BB, GRM = 0)
or: KG, KR, KB, GRM = 1)
Screen background display:
(Screen background color: UG, UR, UB)
(or input image)

Figure 3.3-2 Example of Pattern Background Display *(Continued)*

Note: The font data differs for (1),(2),(3), and (4).
The font data for (1) is designed so that the font is displayed without any change to the dots.
The font data for (2) and (3)is designed taking into consideration the pattern background display.
The font data for (4) is the same as the (1)data except that the font image is shifted to the left by one dot.
The pattern background is influenced by (and influences) the adjacent character patterns on the left and right. Be careful of using the area one or two dots from a character on the left or right .

3.3.2 Solid-fill Background Display

The solid-fill background can be displayed for normal characters on the main screen. Portions other than the character dots in a character area of 24 by 32 dots are displayed in the line background color or the character background color. Specifying the solid-fill background disables the pattern background. Character dot generation, however, depends on the pattern background mode. Whether the solid-fill background should be displayed or not can be specified for each character.

In normal mode, the solid-fill background is displayed in the character background color that is set for each character. In extended graphic mode, it is displayed in the line background color that is set for each line.

The solid-fill background is displayed if 1 is set in the AT bit of Command 1-1 (main screen character control 1) as well as the RB bit of Command 10 (color control). The AT bit can be set for each character. (Here, Command 1-1: BS must be set to 0.)

In normal mode, set the solid-fill background color (character background color) in the BG, BR, and BB bits of Command 1-1 (main screen character control 1). In extended graphic mode, set the solid-fill background color (line background color) in the KG, KR, and KB bits of Command 2-3 (main screen line control 2).

Figure 3.3-3 shows an example of solid-fill background display.

(1) Normal mode:

Command 9	:	GRM = 0
Command 1-1	:	AT = 1, BS = 0
Command 10	:	RB = 1

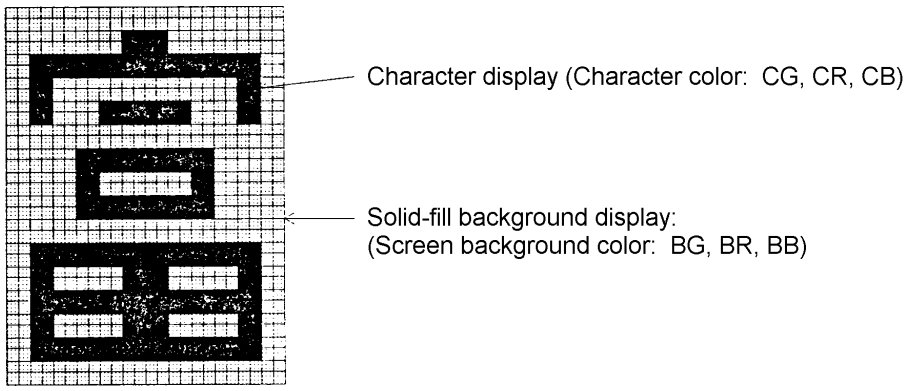


Figure 3.3-3 Example of Solid-fill Background Display

(2) Extended graphic mode:

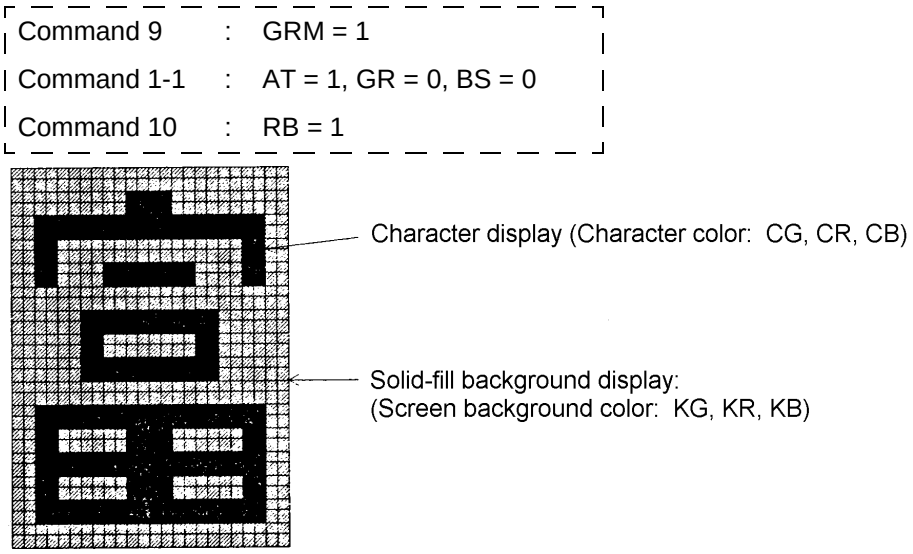

Command 9 : GRM = 1
Command 1-1 : AT = 1, GR = 0, BS = 0
Command 10 : RB = 1
Character display (Character color: CG, CR, CB)
Solid-fill background display:
(Screen background color: KG, KR, KB)

Figure 3.3-3 Example of Solid-fill Background Display *(Continued)*

3.3.3 Shaded Background Display

The shaded background display adds white or black rectangular framing around the solid-fill background display to produce a three-dimensional effect. The shaded background display can be enabled for normal characters in extended graphic mode on the main screen.

For each character, you can specify whether a shaded background should be displayed, whether convex or concave display should be used, what the solid-fill background colors (8) for each line should be, whether the pattern background should be displayed, and what the pattern background colors (8) should be.

If you continuously specify shaded background in the horizontal direction, multiple characters are treated as one block for which shaded background is displayed.

(Multiple characters in the vertical direction cannot be treated as one block.)

A shaded background is displayed if 1 is set in the BS bit of Command 1-1 (main screen character control 1). The solid-fill background color is set in the KG, KR, and KB bits of Command 2-3 (main screen line control 2).

At the same time, a pattern background can be displayed. If the RB bit of Command 10 (color control) is set to 0, a pattern background is used. If the RB bit is set to 1, a pattern background is not used. The pattern background color is set in the PG, PR, and PB bits of Command 1-3 (main screen line control 1).

Shaded background can be selected in either of two ways: convex display, in which an element appears raised from the screen background, and concave display, in which an appears sunken in relation to the screen background. Convex display is selected if the AT bit of Command 1-1 (main screen character control 1) is set to 0. Concave display is selected if the AT bit is set to 1.

Figure 3.3-4 shows an example of shaded background display.

- Shaded background display specification

  Command 1-1 : BS = 1 (Shaded background display specification)

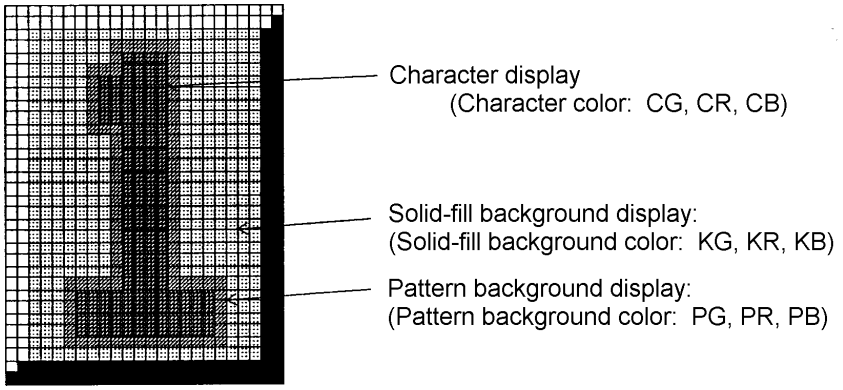
  Command 1-1 : GR = 0 (Normal character display specification)

  Command 9 : GRM = 1 (Extended graphic mode specification)

(1) Example of shaded background display (Convex display with a pattern background)

Command 1-1 : AT = 0 (Specifying convex display)

Command 10 : RB = 0 (Specifying that there is a pattern background)


Character display
(Character color: CG, CR, CB)
Solid-fill background display:
(Solid-fill background color: KG, KR, KB)
Pattern background display:
(Pattern background color: PG, PR, PB)

(2) Example of shaded background display (Concave display with a pattern background)

Command 1-1 : AT = 1 (Specifying concave display)

Command 10 : RB = 0 (Specifying that there is a pattern background)

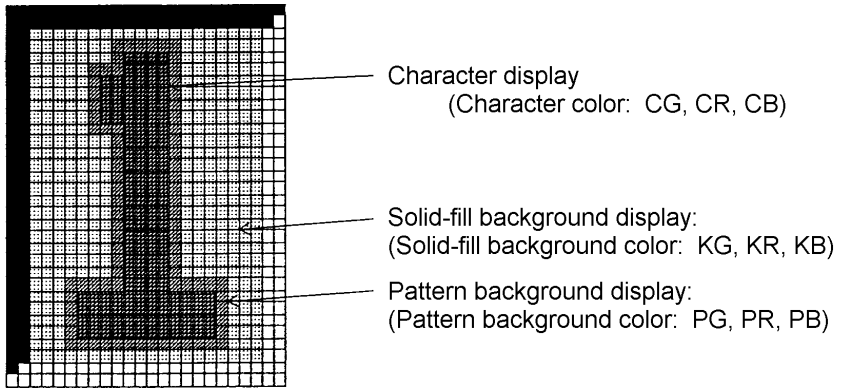
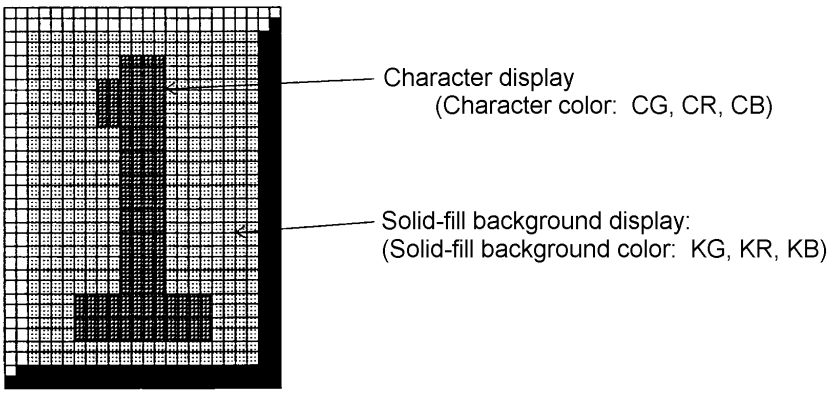

Character display
(Character color: CG, CR, CB)
Solid-fill background display:
(Solid-fill background color: KG, KR, KB)
Pattern background display:
(Pattern background color: PG, PR, PB)

Figure 3.3-4 Example of Shaded Background Display

(3) Example of shaded background display (Convex display without a pattern background)

Command 1-1 : AT = 0 (Specifying convex display)

Command 10 : RB = 1 (Specifying that there is no pattern background)



(4) Example of shaded background display (Concave display without a pattern background)

Command 1-1 : AT = 1 (Specifying concave display)

Command 10 : RB = 1 (Specifying that there is no pattern background)

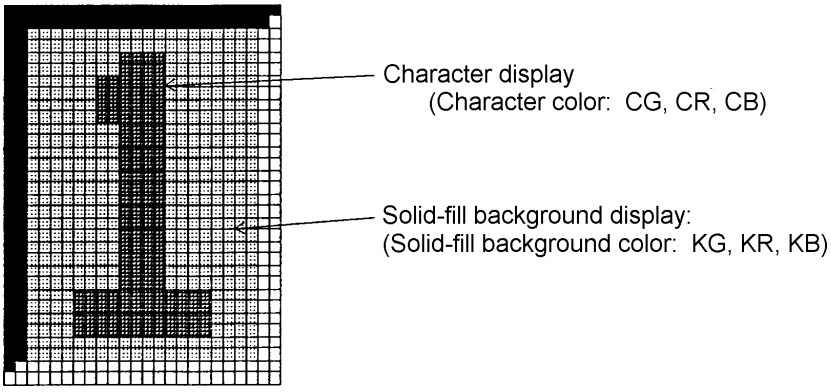


Figure 3.3-4 Example of Shaded Background Display *(Continued)*

3.3.4 Blinking Display

Blinking display is a display mode in which display and no display alternate every 32 Vs (vertical cycles). Whether blinking display should be used can be specified for each character.

If 1 is set in the BK bit of Command 10 (color control), blinking display is specified for the character for which 1 is set in the AK bit of Command 1-1 (main screen character control 1). (However, if BS bit = 1 in Command 1-1, blinking display is not used.)

For blinking display of a pattern background character, the character dots and the pattern background dot blinks. For blinking display of a solid-fill background character, the character dots and the solid-fill background dots blinks.

3.3.5 Kanji Font Display

The MB90092 provides kanji font display control functions that optimize the display of a kanji font of 24 by 24 dots or 16 by 16 dots (such as a kanji ROM font).

The kanji font display control functions include the kanji font area control, 16/24-dot font control, kanji font pattern background control, kanji font boldface character control, and kanji font display position control.

(1) Kanji Font Area Control

This function specifies the area in which kanji font control is performed. Control of the RM1 and RM0 bits of the kanji font display control (Command 9) selects an option from among no kanji font area, 4 megabits (character codes: 0000_H to $0FFF_H$), and 8 megabits (character codes: 0000_H to $1FFF_H$). Specify an optimal area size appropriate for the kanji font size used.

Note that if normal or graphic characters other than a kanji font is set in the kanji font area, these characters will not be displayed correctly.

(2) Kanji Font 16/24-dot Font Control

This function specifies the dot format of the kanji font to be used. A font of 16 by 16 dots or 24 by 24 dots can be selected.

Figure 3.3-5 shows the 16-dot font display configuration (example of displaying one character).

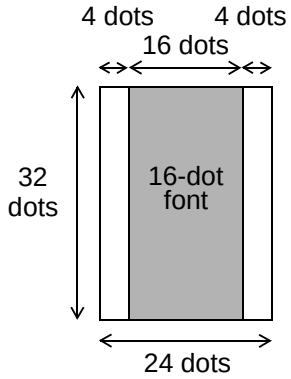


Figure 3.3-5 16-dot Font Display Configuration

If a font of 24 by 24 dots is selected (kanji font display control (Command 9: S16 = 0), see (5), “Kanji font display position control.”

(3) Kanji Font Pattern Background Control

This function specifies the pattern background mode in which a character in the kanji font area is displayed. The following table shows the relationship of the RP1 and RP0 bits of the kanji font display control (Command 9) and the pattern background mode.

RP1	RP0	Pattern background mode
0	0	Depends on the settings in P2 and P0 in Command 4.
0	1	Horizontal framing 1 (Same as pattern background 3) (One-dot framing on the right and left sides of a character dot)
1	0	Horizontal framing 2 (Two-dot framing on the right and left sides of a character dot)
1	1	(Do not use this setting.)

Figure 3.3-6 shows examples of horizontal framing display.

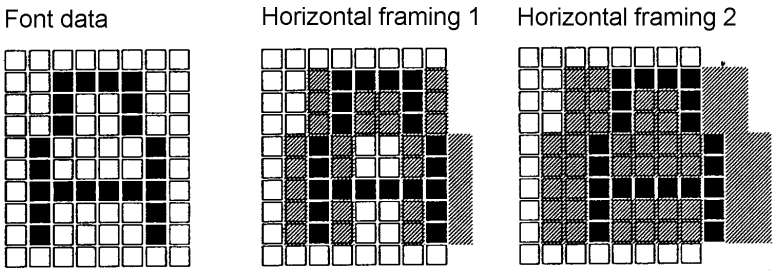


Figure 3.3-6 Examples of Horizontal Framing Display

Notes:

1. - With horizontal framing 1, the character dot is shifted one dot to the right.
   - With horizontal framing 2, the character dot is shifted two dots to the right.
   - If horizontal framing and a character in another display mode are adjacent, the display may not be correct.
2. If a character dot is set as the rightmost dot (24th dot) or the dot before the rightmost one (23rd dot) in the horizontal 24-dot character area, the pattern background dot may leave the character area and be displayed in the adjacent character area on the right. However, the pattern background never extends beyond the right edge of the character display screen area (24th dot of the 24th character).

(4) Kanji font boldface character control

The kanji font boldface character control enlarges the character dots horizontally by one dot. The character size is not changed.

Figure 3.3-7 shows an example of boldface character display.

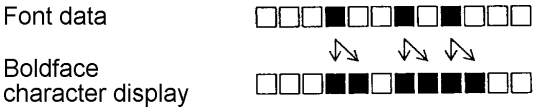


Figure 3.3-7 Example of Boldface Character Display (Displaying Twelve Dots in the Horizontal Direction)

Notes:

1. This specification replaces a non-character dot with a character dot, causing continuous character dots to be displayed.
   Do not use this specification for a font created in relation to pattern backgrounds 1 and 2.

2. If a character dot is set as the rightmost dot (24th dot) in the horizontal 24-dot character area, the character dot added for boldfacing leaves the character area and is displayed in the adjacent character area on the right. However, the character dot never extends beyond the right edge of the character display screen area (24th dot of the 24th character). The same applies to a pattern background dot in the pattern background display.

(5) Kanji Font Display Position Control

This function selects the display mode (vertical display position) used when a character of 24 by 24 dots in the kanji font area is displayed. The DW4 bit of the kanji font display control (Command 9) is used for control.

Figure 3.3-8 shows the display position control modes.

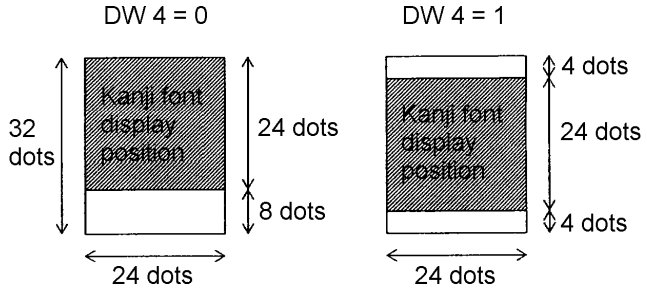


Figure 3.3-8 Display Position Control Modes

3.4 Graphic Character Display Functions

The MB90092 can display graphic characters as well as normal characters. Graphic characters consist of 8 × 32 dots each of which can be displayed in the color selected from among eight different colors. Color display information is included in font data. The character size is the same as that of normal characters. (One dot for graphic characters is equivalent to three dots for normal characters.)

Graphic character display has the following features:

- Dot configuration : 8 × 32 dots (horizontal × vertical)
- Main screen display
  - Display control : Normal and graphic characters selected for each character can be displayed at the same time.
    (Mixed display enabled only in extended graphics mode)
  - Display character color : 8 colors (for each dot) × 4 phases (for each character)
    or 8 gradient colors (color or monochrome specified for the entire screen)
- Sub-screen display
  - Display control : Normal and graphic characters selected for each line can be displayed at the same time.
    (Mixed display enabled only in extended graphics mode)
  - Display character color : 8 colors (for each dot) × 4 phases (for each line)
    or 8 gradient colors (color or monochrome specified for the entire screen)

Note: Do not specify graphic display for those characters in the kanji font area. Otherwise, they cannot be displayed correctly.

CHAPTER 4 CONTROL FUNCTION

This chapter describes the display control functions of the MB90092.
The MB90092 has two modes of operation: internal sync controlled and external sync controlled operation.
In internal sync controlled operation, the device generates horizontal/vertical sync signals and a character signal, as well as a video signal for color display.
In external sync controlled operation, it generates a character signal for superimposed display.

4.1 Dot Clock Generator
4.2 Color Burst Clock Generator
4.3 Power-on Reset
4.4 Analog Switch Circuit
4.5 Sync Control
4.6 External Sync Control
4.7 Display Signal Output Timing
4.8 Command Write Sequence
4.9 Command/Data Transfer
4.10 Command Transfer Sequence and Timing
4.11 Font Memory

4.1 Dot Clock Generator

The dot clock serves as the fundamental clock for character display. Since the dot clock must be phase-synchronized with the video signal, the dot clock uses an LC-tuned oscillator with its oscillation stopped and restarted by the horizontal sync signal for phase synchronization.

Figure 4-1-1 shows the dot clock oscillation waveform.

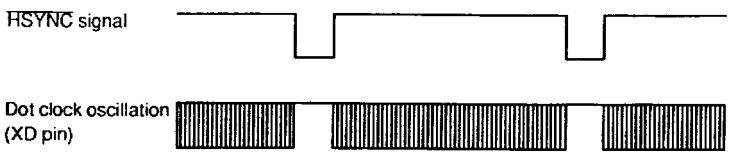


Figure 4.1-1 Dot Clock Oscillation Waveform

The LC-tuned oscillator circuit for the dot clock is shown in Figure 4-1-2. Since this circuit must be oscillated synchronously with the rising edge of the HSYNC signal, it cannot be built with a crystal or ceramic oscillator.

Since the character display positions on the screen are proportional to the dot clock period (1/frequency), it is necessary to adjust the clock period by using a trimmer or other variable capacitor on the EXD side if fluctuations in display positions present a problem for your application. (The capacitor on the XD side can be a fixed one.)

Set the adjustment range with some allowance by considering variations in L and C.

When adjusting the frequency, use the oscillator output for the dot clock from the VSYNC pin for reference. This output is obtained by driving the TEST pin low. When adjusted to approximately 14 MHz, you can display characters normally over the entire screen.

Figure 4-1-2 shows an internal equivalent circuit of the dot clock generator.

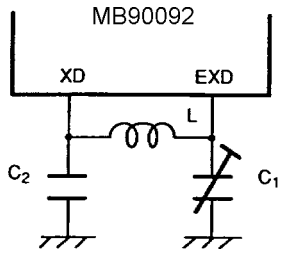


Figure 4.1-2 LC-Tuned Dot Clock Oscillator

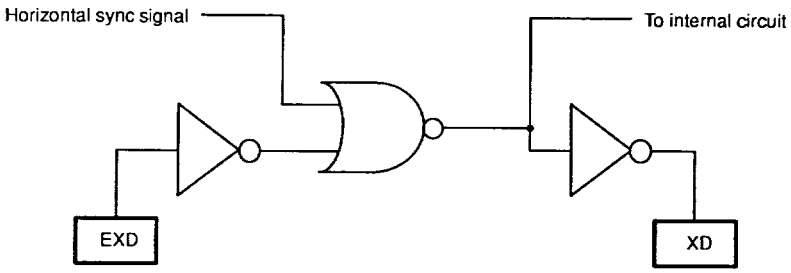


Figure 4.1-3 Equivalent Circuit of Dot Clock Generator

4.2 Color Burst Clock Generator

The color burst clock functions as the basic clock for the sync and the color burst signals during internal sync control (internal video signal). Note that the internal sync control system is operating even during external sync control to control the horizontal and vertical blanking.

Concerning the crystal oscillator circuit for the color burst clock, make sure that the capacitors fitted to both ends of the crystal resonator meet the capacitance requirements stipulated for the crystal resonator used.

Since the color burst clock is the source for the internally generated video signal color burst and chroma carrier, it is generally required of extremely high frequency accuracy. Therefore, it is recommended that the capacitance on either side of the EXS or the XS pins be made adjustable by using, for example, a trimmer capacitor. In most applications, this trimmer capacitor may be fitted on the EXS pin side where it is easier to adjust capacitance without adversely affecting its balance. This is because if load capacitance in a crystal oscillator circuit is excessively unbalanced, the temperature and other oscillation characteristics tend to deteriorate.

For the fixed capacitor on the XS pin side, use a ceramic or other appropriate capacitor that has the smallest temperature coefficient possible.

When adjusting the frequency, use the oscillator output for the color burst clock from the $\overline{\text{HSYNC}}$ pin (divided by 4) for reference. This output is obtained by driving the $\overline{\text{TEST}}$ pin low.

Figure 4-2-1 shows a crystal oscillator circuit of the color burst clock.

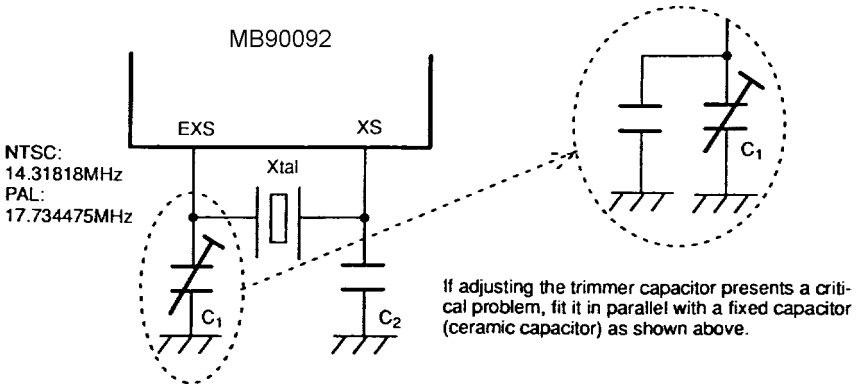


Figure 4.2-1 Crystal Oscillator Circuit

4.3 Power-on Reset

4.3.1 Power-on Reset

A power-on reset means that the device generates an internal reset signal to initialize its operation upon detection of power-on.

Input the $\overline{CS}$ signal four times to clear a power-on reset.

Figure 4-3-1 shows a timing of how a power-on reset is cleared.

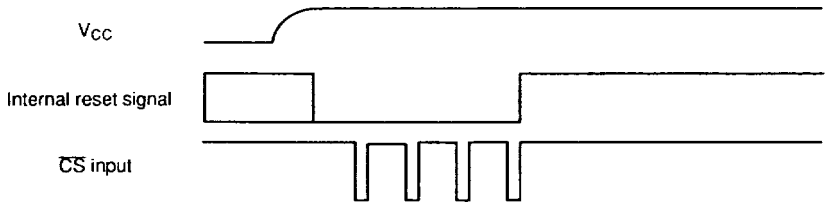


Figure 4.3-1 Clearing Power-on Reset

4.3.2 Device Initialization

When reset at power-on, the MB90092's screen control 1(command4) has its IE (internal/ external sync control) bit and DC (display control) bit cleared to 0, and screen display is turned off under internal sync control.

After power-on, clear a power-on reset first. Then, set the screen control 1(command4) DC bit to 1 to turn display on after setting all register data and all VRAM contents to be displayed.

4.4 Analog Switch Circuit

The MB90092 contains an analog switch circuit which allows you to synthesize character information on a video signal input from the VIN, YIN, or CIN pins or an internally generated video signal and output the result via the VOUT, YOUT, and COUT pins.

Figure 4-4-1 shows a block diagram of the analog switch circuit.

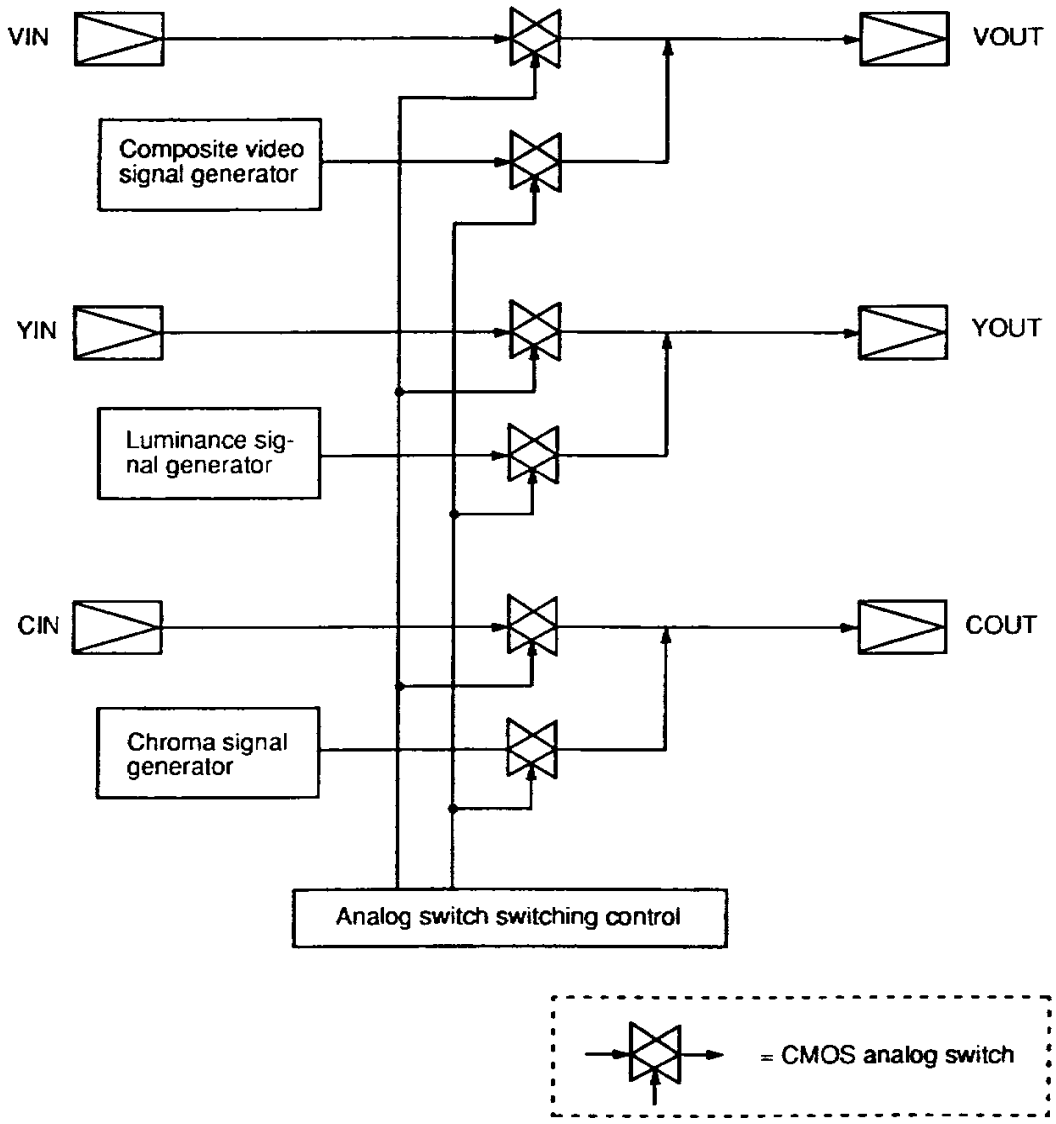


Figure 4.4-1 Analog Switch Circuit

4.5 Sync Control

The MB90092 has two modes of operation: external sync controlled and internal sync controlled operation. The external sync mode is used for superimposed display by synthesizing an externally input video signal (sync signal) with characters. The internal sync mode is used to display characters after synthesizing them with an internally generated video signal (sync signal), that is, a signal generated by the MB90092's internal video signal (sync signal) generator.

Video output during internal sync controlled operation can be displayed in color.

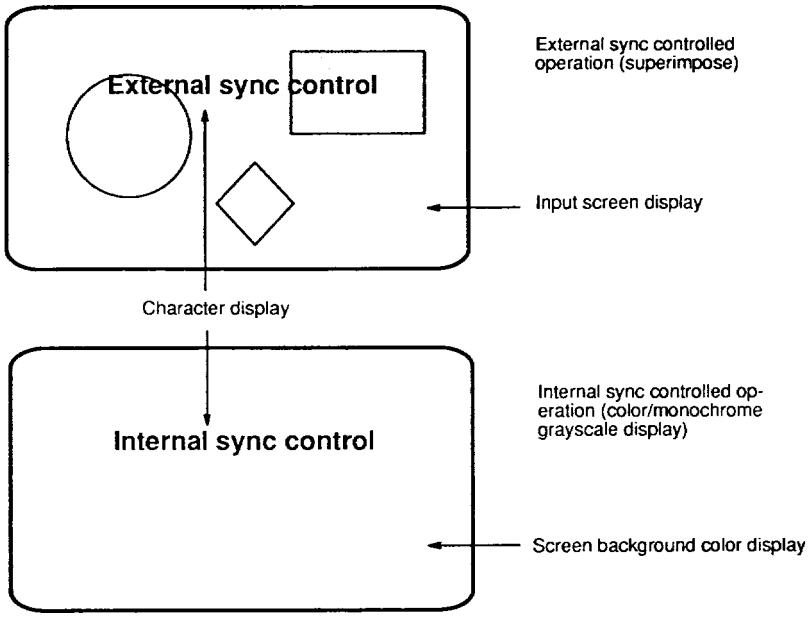


Figure 4.5-1 External Sync and Internal Sync Display

4.6 External Sync Control

External sync control produces superimposed display by phase-synchronizing the MB90092's internal sync signal with an external sync signal. The external sync signal can be a H/V separate sync or a composite sync signal.

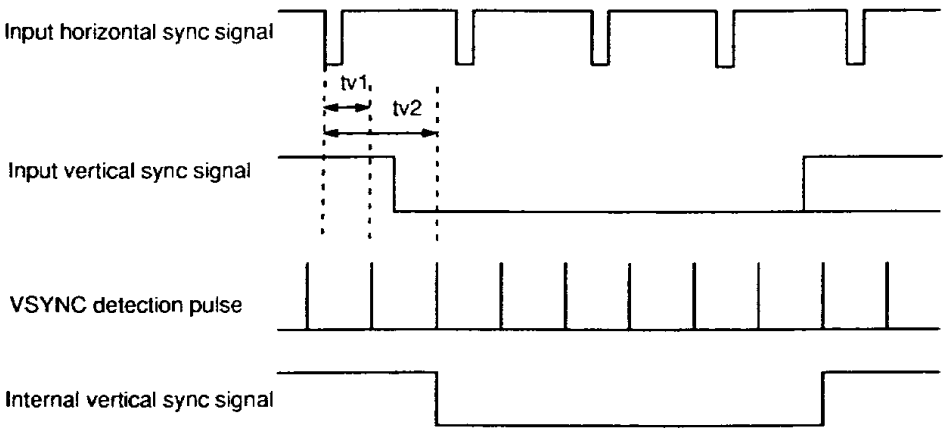
4.6.1 H/V Separate Sync Signal Input

By setting the SC bit of the horizontal display start position register (command 8) to 1, the $\overline{\text{EXHSYN}}$ pin can be used for horizontal sync signal input and the $\overline{\text{EXVSYN}}$ pin for vertical sync signal input, respectively.

The $\overline{\text{EXHSYN}}$ pin contains a filter to cut signals below 3 µs to eliminate noise and other unwanted components.

Vertical synchronization is detected by the internal VSYNC detection pulse. If a falling edge of the vertical sync signal occurs near this VSYNC pulse, a 1H delay may result, causing a vertical drift in character display.

Figure 4-6-1 shows how the vertical sync is detected.



- For NTSC
  tv1 = 340 (4FSC clock) = approx. 23.8 µs
  tv2 = 796 (4FSC clock) = approx. 55.6 µs

- For PAL
  tv1 = 426 (4FSC clock) = approx. 24.0 µs
  tv2 = 994 (4FSC clock) = approx. 56.0 µs

Figure 4.6-1 Vertical Sync Detect Operation

4.6.2 Composite Sync Signal Input

By setting the SC bit of the horizontal display start position register (command 8) to 0, the EXHSYN pin can be used for composite sync signal input.

Vertical synchronization is detected by measuring the pulse width of the signal input to the EXHSYN pin. When the pulse width of the signal input to the EXHSYN pin is equal to or greater than 13 µs, the signal is assumed to be the vertical sync pulse; when equal to or greater than 4 µs, it is assumed to be the horizontal sync pulse. Signals 3 µs or less in pulse width are ignored as noise.

Figure 4-6-2 shows the internal timing of sync separate operation.

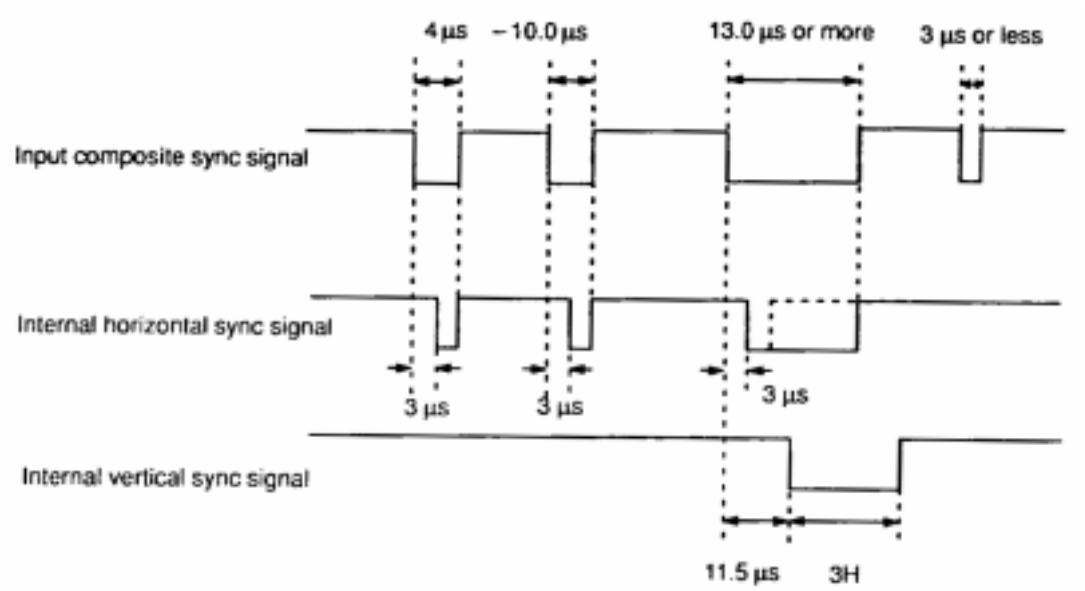


Figure 4.6-2 Internal Timing of Sync Separate Operation

4.7 Display Signal Output Timing

The MB90092 pins output the display periods and display colors using digital signals.

The B, R, and G pins output signals indicating the display color. A valid color is output during the output period for display color, pattern background color, solid-fill background color, graphic character color, and screen background color.

The VOC pin designates the output period for characters (only character dots) and graphic characters.

The VOB pin designates the output period for characters, pattern backgrounds, solid-fill backgrounds, and screen backgrounds.

Figure 4.7-1 shows an example of display signal output timing for the following settings:

Character color settings	(CG, CR, CB) = (1, 0, 0)
Solid-fill background color settings	(BG, BR, BB) = (0, 0, 1)
Screen background color settings	(UG, UR, UB) = (0, 1, 1)

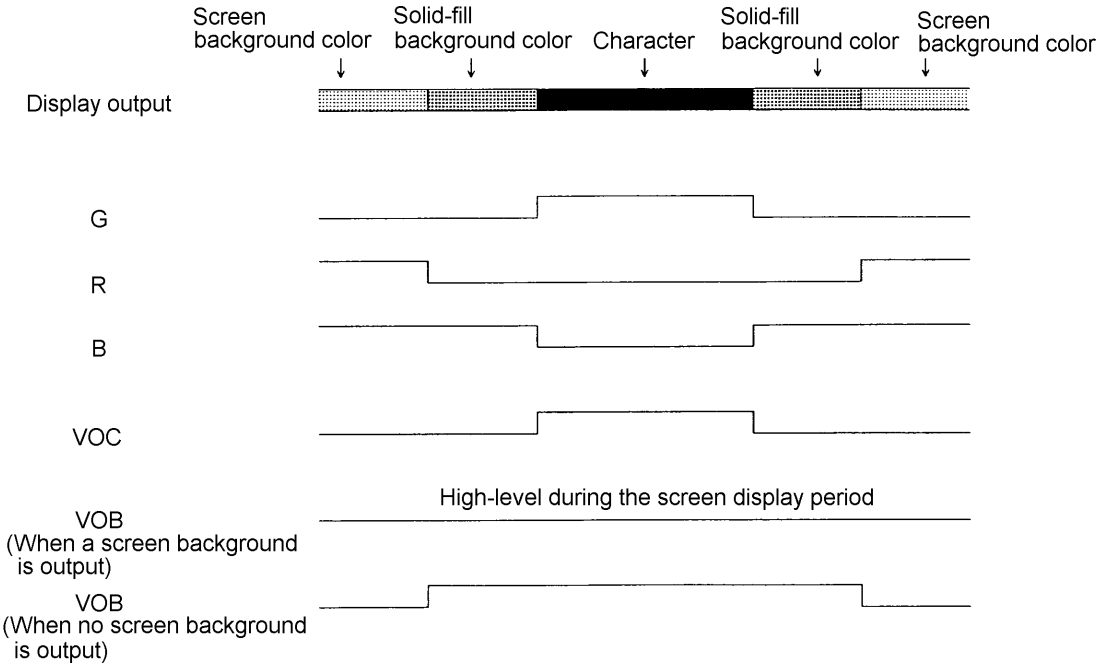


Figure 4.7-1 Display Signal Output Timing

4.8 Command Write Sequence

The MB90092's each command consists of two bytes, with the first byte containing “command ID code + high-order bits of data” and the second byte containing “data.”

In serial transfer, each command is transferred in order of the first and the second bytes. Since the first byte is internally retained into a latch, it is possible to transfer two or more second bytes in succession after transferring the first byte.

Figure 4-8-1 shows a command write sequence.

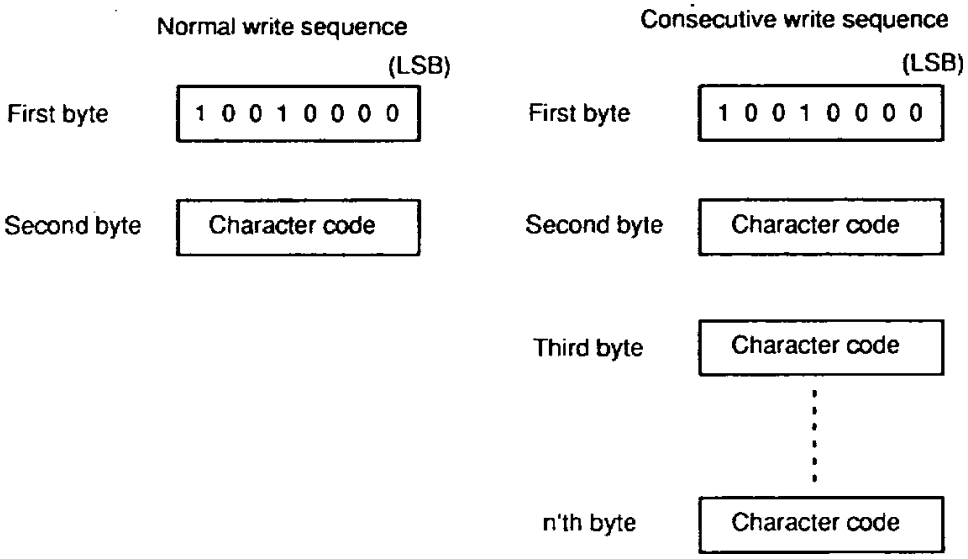


Figure 4.8-1 Command Write Sequence (for Command 2-1)

4.9 Command/Data Transfer

Display control commands and data are transferred to the MB90092's internal registers via 8-bit serial transfer. This serial transfer is done by using three signals: $\overline{CS}$ (chip select), SCLK (shift clock), and SIN (serial input).

Figure 4-9-1 shows the signal timing during serial transfer.

The $\overline{CS}$ pin is for the chip select signal, and is set low for serial transfer. The SIN pin is for the serial data input signal. The SCLK pin is for the shift clock signal for data reception.

The data is 8 bits long, and is sequentially shifted in to the SIN pin beginning with the least significant bit (LSB). The data is latched and shifted in on each rising edge of the shift clock input to the SCLK pin as shown in Figure 4-9-1. The transferred data is loaded into the internal register on the rising edge of the shift clock at the eighth bit and processed as command or data. Therefore, commands and data can be written into the MB90075 at any timing.

In serial transfer, the number of received bits is counted by shift clock counts. Serial transfer may be reset by forcing $\overline{CS}$ pin high; this reset can be cleared by forcing the $\overline{CS}$ pin from high to low so that the subsequent eight bits of data (eight shift clock counts) are handled as byte data. Thus, it is possible to maintain byte synchronization by using the $\overline{CS}$ pin.

If the $\overline{CS}$ signal is released back high before eight bits of data are transferred, the data becomes invalid.

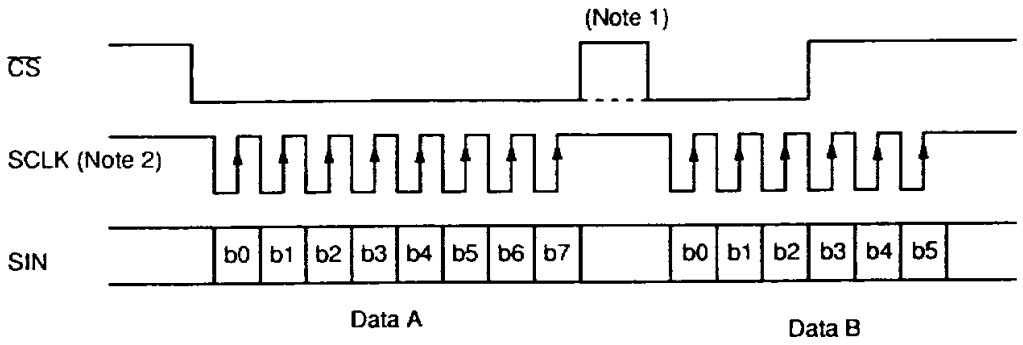


Figure 4.9-1 Serial Transfer Timing

Data A is written into the internal register since the $\overline{CS}$ pin is held low. However, data B is ignored because the $\overline{CS}$ pin is released back high in the middle of data transfer.

Notes:

1: To maintain byte synchronization, the $\overline{CS}$ pin should be temporarily returned high and then set low before starting serial data transfer.

2: Just after the power-on, please force the SCLK pin to “H” before the serial data transfer.

4.10 Command Transfer Sequence and Timing

No restrictions are imposed on the sequence of command and data transfer, so the registers can be set in any order. (However, register settings in command 0 and command 1 are made effective by issuing command 2.)

The MB90092's register and VRAM contents are rewritten simultaneously when a command and data are accepted and reflected in display operation. Consequently, if the contents of any register are altered while characters are displayed on the screen, the display of that frame may be disturbed. (When the same contents are written, display is generated normally without disturbance.) Display disturbance occurs in only one frame, and display is produced normally from the next frame onward.

Generally, the following rules may be observed when transferring commands and data.

- When powered on, do not turn display on (command 4; screen control 1 DC bit = 1) until after data is set in all registers and VRAM.
- When setting commands that change the screen display such as the VRAM data set etc, we recommend that commands are performed in the display-OFF state.
- If possible, make sure that issue of commands are done during the vertical blanking interval synchronously with the vertical sync signal.

For writing display data to VRAM, you need not be concerned about the write timing if the device is used under normal conditions (write frequency equivalent to refreshing display memory at a period of several 10ms to a few seconds).

However, for applications where the MB90092 outputs are recorded on video tape and reproduced after being decomposed frame by frame, changes in the settings of commands must be made synchronously with the vertical sync signal during the vertical blanking interval before the display position is reached.

4.11 Font Memory

4.11.1 Font Memory Configuration

One character requires 128 bytes of font memory (and 96 bytes for character data). Up to 16 megabits of memory can be provided externally, and up to 16,384 character types can be used.

Normal and graphic characters can be mixed and set for any character code (address).

Figure 4.11-1 shows the font memory configuration.

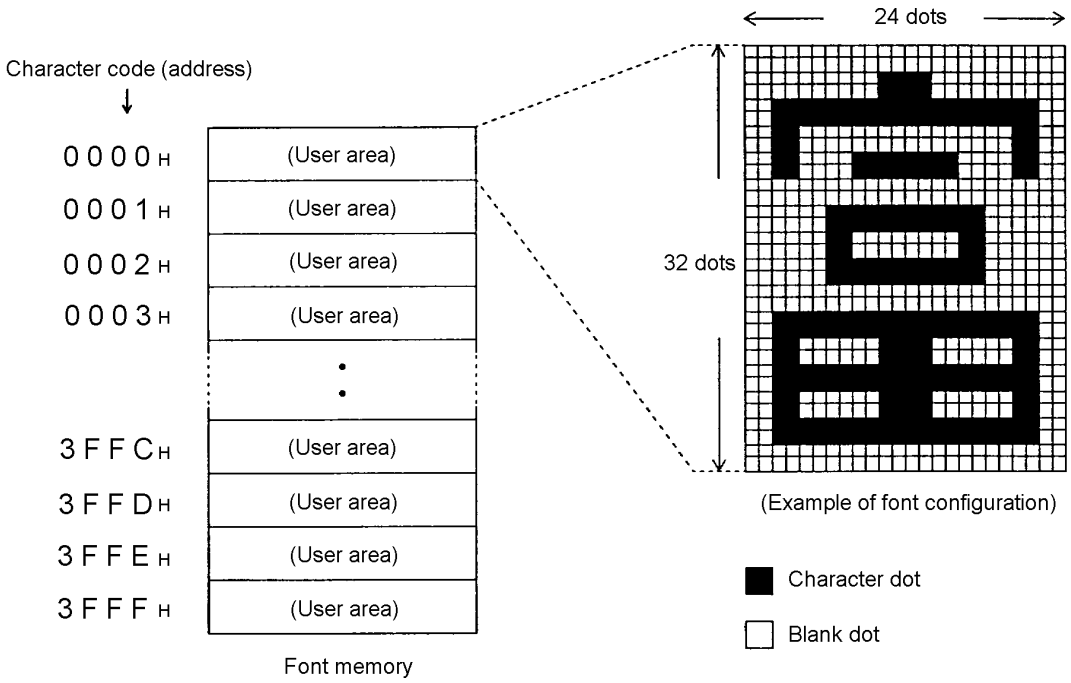


Figure 4.11-1 Font Memory Configuration

4.11.2 Kanji Font Area Control

A kanji ROM font of 16 by 16 dots or 24 by 24 dots must be set in the kanji font area so that kanji font area control can be performed on it. The kanji font area is set to character codes (addresses) 0000_H to $0FFF_H$ (4 megabits) or 0000_H to $1FFF_H$ (8 megabits) depending on the specification in RM1 and RM0 of the kanji font display control (Command 9). A kanji ROM font for which no kanji font display control is performed can be set to any character codes (addresses) that are not the highest-order codes. Be careful that a non-kanji font character (including a graphic character), if set in the kanji font area, will be displayed correctly. If no kanji font display control need be performed in any of the areas, specify that no kanji font is used. Figure 4.11-2 shows an example of kanji font area specification.

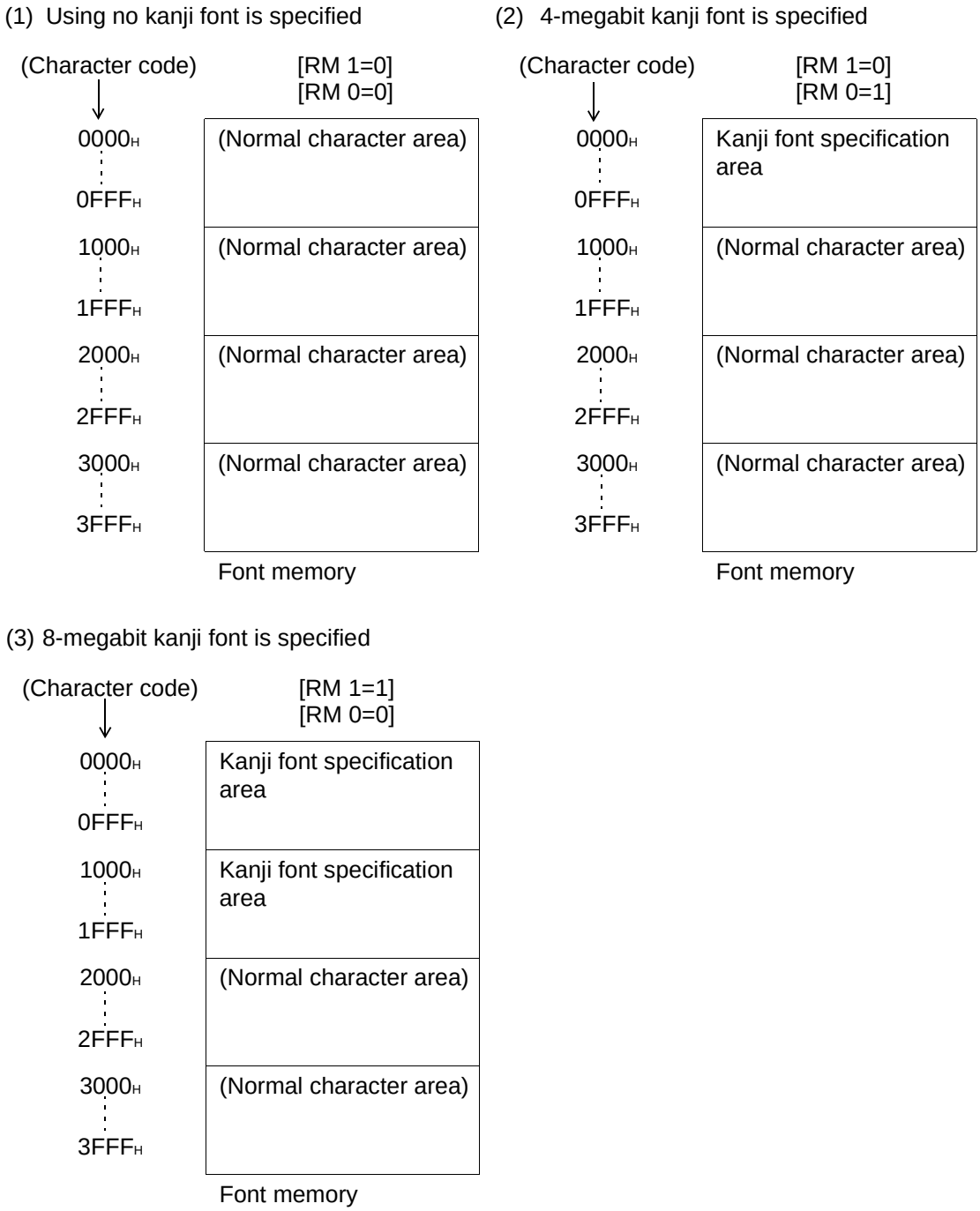
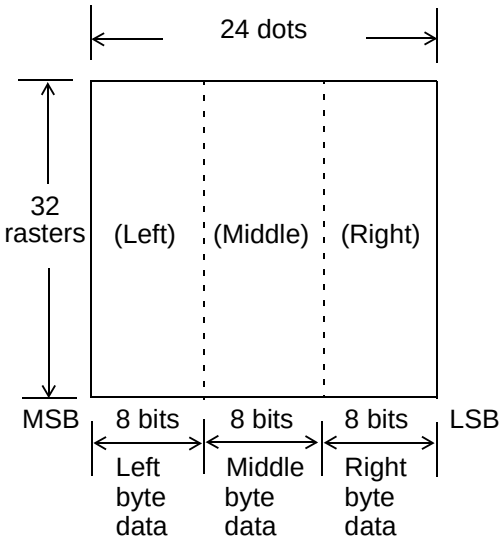


Figure 4.11-2 Example of Kanji Font Area Specification

4.11.3 Font Data Configuration

Figures 4.11-3 and 4.11-4 show the font data configuration and the font memory address configuration.

(1) Normal character font (24 by 32 dots)



(2) Graphic character font (8 by 32 dots)

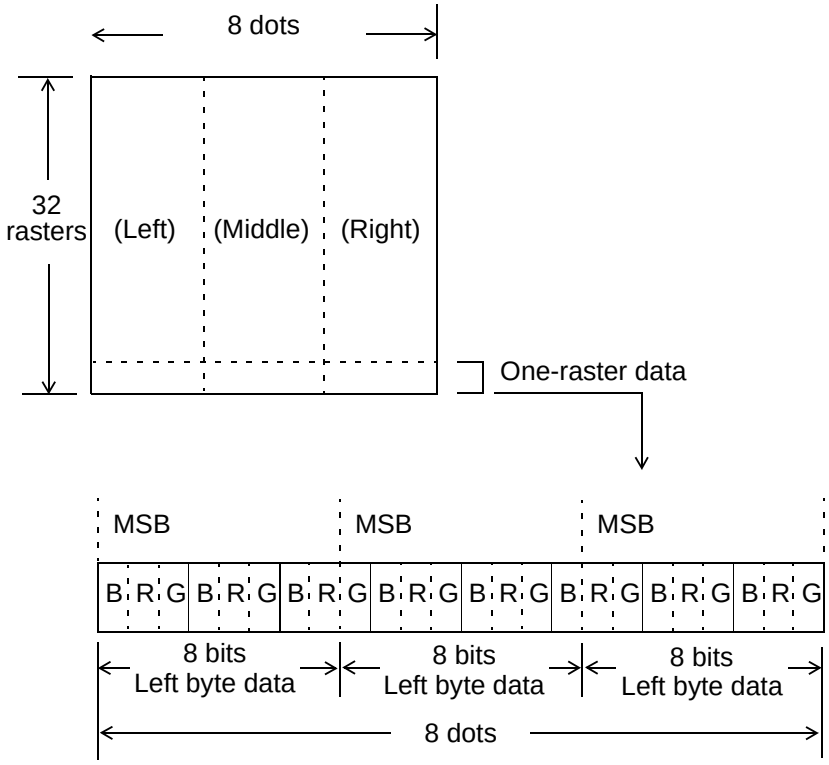


Figure 4.11-3 Font Data Configuration

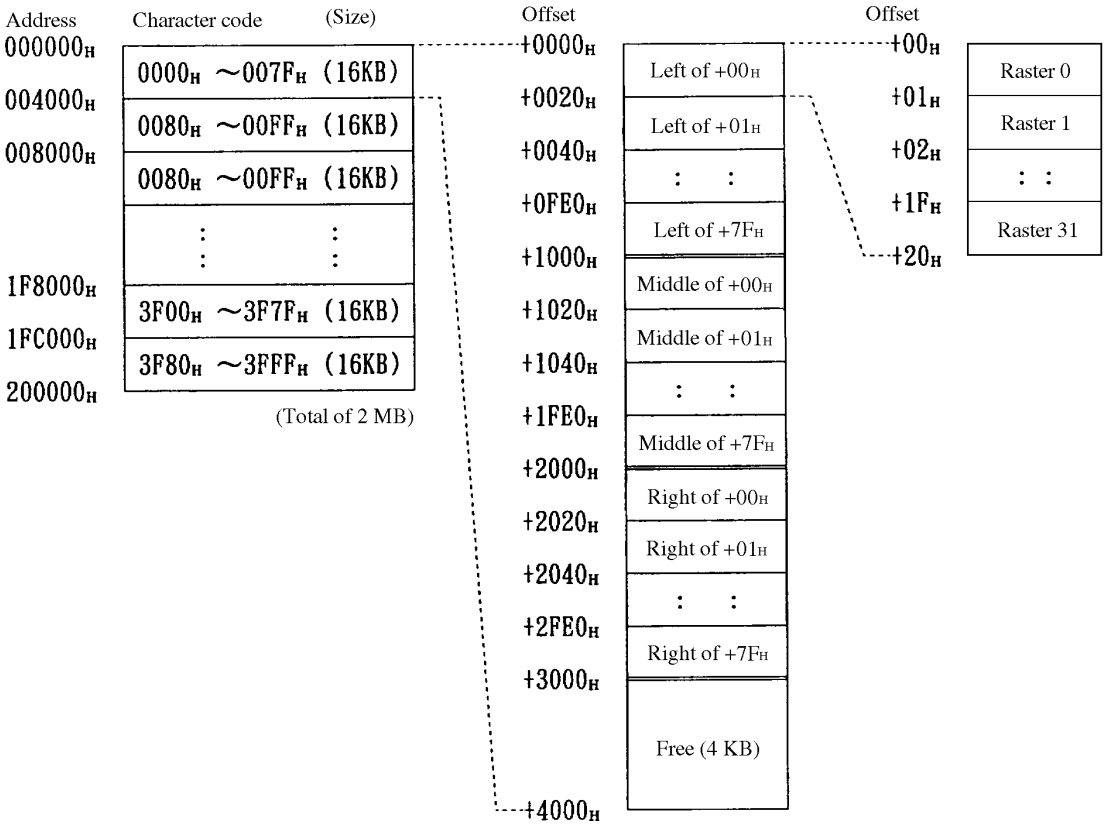


Figure 4.11-4 Font Memory Address Configuration

CHAPTER 5 DISPLAY CONTROL COMMANDS

Chapter 5 describes the display control commands of the MB90092.
The MB90092 is provided with the following:

- **VRAM address setting (Command 0),**
- **Main screen character control 1 (Command 1-1),**
- **Main screen character control 2 (Command 2-1),**
- **Sub-screen line control 1 (Command 1-2),**
- **Sub-screen line control 2 (Command 2-2),**
- **Main screen line control 1 (Command 1-3),**
- **Main screen line control 2 (Command 2-3),**
- **VRAM write control (Command 3),**
- **Screen control 1 (Command 4),**
- **Screen control 2 (Command 5),**
- **Main screen line control 3 (Command 6),**
- **Main screen vertical position control (Command 7),**
- **Main screen horizontal position control (Command 8),**
- **Kanji font display control (Command 9),**
- **Color control (Command 10),**
- **Sub-screen control (Command 11),**
- **Sub-screen vertical position control (Command 12)**
- **Sub-screen horizontal position control (Command 13)**

5.1 Display Control Commands
5.2 Command 0 (VRAM Address Setting)
5.3 Commands 1 and 2 (VRAM Data Settings 1 and 2)
5.4 Command 3 (VRAM Write Control)
5.5 Command 4 (Screen Control 1)
5.6 Command 5 (Screen Control 2)
5.7 Command 6 (Main Screen Line Control)
5.8 Command 7 (Main Screen Vertical Display Position Control)
5.9 Command 8 (Main Screen Horizontal Display Position Control)
5.10 Command 9 (Kanji Font Display Control)
5.11 Command 10 (Color Control)
5.12 Command 11 (Sub-Screen Control)
5.13 Command 12 (Sub-Screen Vertical Position Control)
5.14 Command 13 (Sub-Screen Horizontal Position Control)

5.1 Display Control Commands

Table 5.1-1 lists the MB90092 display control commands.

Table 5.1-1 List of Display Control Commands

Command no.	First byte				Second byte								Function
	Command code/data				Data								
	76543	2	1	0	7	6	5	4	3	2	1	0	
0	10000	VSL	RA8	RA7	0	RA6	RA5	CA4	CA3	CA2	CA1	CA0	VRAM address setting
1-1	10001	MA	MB	AT	0	CG	CR	CB	MC	BG (GR)	BR (BS)	BB (MD)	Main screen character control 1*
2-1	10010	M9	M8	M7	0	M6	M5	M4	M3	M2	M1	M0	Main screen character control 2
1-2	10001	SMA	SMB	0	0	SCG	SCR	SCB	SMC	SGR	SDC	SMD	Sub-screen line control 1
2-2	10010	SM9	SM8	SM7	0	SM6	SM5	SM4	SM3	SM2	SM1	SM0	Sub-screen line control 2
1-3	10001	OF1	OF0	0	0	0	0	0	PC	PG	PR	PB	Main screen line control 1
2-3	10010	G2	G1	G0	0	SOC	VD	DG	KC	KG	KR	KB	Main screen line control 2
3	10011	FIL	0	0	0	0	0	0	0	0	0	0	VRAM write control
4	10100	IE	IN	EB	0	EO	CM	ZM	NP	P2	P0	DC	Screen control 1
5	10101	KID	APC	GYZ	0	BH2	BH1	BH0	W3	W2	W1	W0	Screen control 2
6	10110	G2	G1	G0	0	SOC	VD	DG	N3	N2	N1	N0	Main screen line control 3
7	10111	EC	LP	FO	0	0	Y5	Y4	Y3	Y2	Y1	Y0	Main screen vertical position control
8	11000	SC	0	FC	0	0	X5	X4	X3	X2	X1	X0	Main screen horizontal position control
9	11001	0	0	GRM	0	0	0	0	0	0	0	0	Kanji font display control
10	11010	0	0	RB	0	BK	CC	BC	UC	UG	UR	UB	Color control
11	11011	SG2	SG1	SG0	0	0	SCC	SBC	SGC	SBG	SBR	SBB	Sub-screen control
12	11100	SGA	0	SY7	0	SY6	SY5	SY4	SY3	SY2	SY1	SY0	Sub-screen vertical position control
13	11101	0	SX8	SX7	0	SX6	SX5	SX4	SX3	SX2	SX1	SX0	Sub-screen horizontal position control
14	11110	—	—	—	0	—	—	—	—	—	—	—	(Reserved)

Table 5.1-1 List of Display Control Commands

15	11111	—	—	—	0	—	—	—	—	—	—	—	(Reserved)

*: Parenthesized bit names are used for extended graphics mode.

5.2 Command 0 (VRAM Address Setting)

[Command format]

	MSB							LSB
First byte	1	0	0	0	0	VSL	RA8	RA7
	MSB							LSB
Second byte	0	RA6	RA5	CA4	CA3	CA2	CA1	CA0

VSL : VRAM write control
RA8 to RA5 : VRAM row address setting (00 to B_H)
CA4 to CA0 : VRAM column address setting (00 to 17_H)

[Function]

This command sets the VRAM address. The write address must be specified using this command before data can be written by command 1 and command 2.

[Description]

This command sets the character control RAM address and line control RAM address of the main screen, and the line control RAM address of the sub-screen. The operation is selected according to the settings in the VSL and CA0 bits.

The VRAM address is automatically incremented by writing character code data (by command 2). VRAM address is specified by A8 to A0 bits.

VSL : VRAM write control

RA8 to RA5 : VRAM row address setting (0 to B_H)

CA4 to CA0 : VRAM column address setting (00 to 17_H)

VSL	RA8 RA7 RA6 RA5	CA4 CA3 CA2 CA1 CA0	Operation
0	Row address (0 to B_H)	Column address (0 to 17_H)	Set the main screen character control RAM address.
1	Row address (0 to B_H)	— — — — 0	Set the sub screen row control RAM address.
	Row address (0 to B_H)	— — — — 1	Set the main screen row control RAM address.

RA8-RA5 specify the row address; CA4-CA0 specify the column address.

Valid column addresses are 00_H to 17_H.

Valid row addresses are 0_H to B_H.

Do not specify any other column or row addresses.

Figure 5.2-1 shows the VRAM configuration.

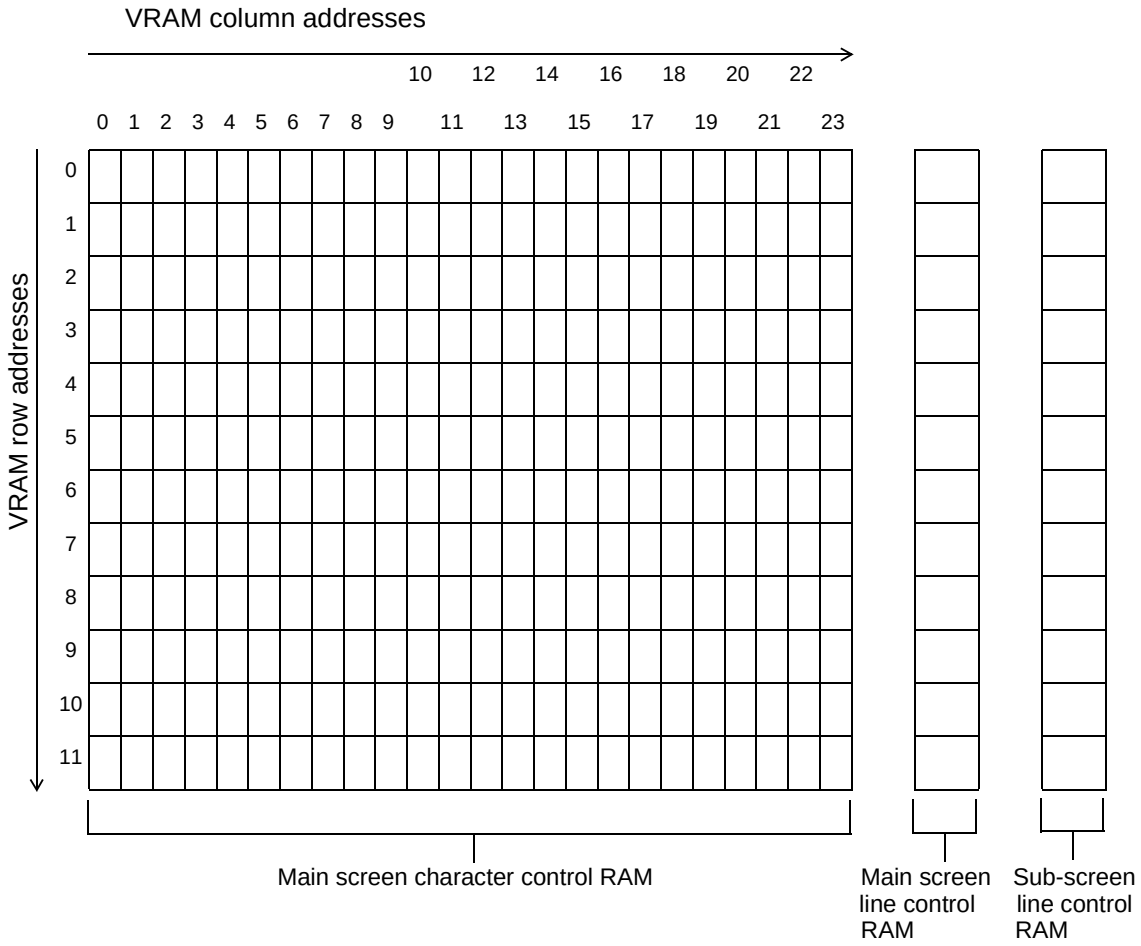

VRAM column addresses
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23
VRAM row addresses
0 1 2 3 4 5 6 7 8 9 10 11
Main screen character control RAM
Main screen line control RAM
Sub-screen line control RAM

Figure 5.2-1 VRAM Configuration

5.3 Commands 1 and 2 (VRAM Data Settings 1 and 2)

The contents of Commands 1 and 2 are set to main screen character control data write, main screen line control data write, or sub-screen line control data write according to the settings of the VSL and CA0 bits of Command 0.

Before these commands are issued, the VRAM write address must be specified using Command 0. Issuing Command 2 saves the contents of Command 1 in VRAM and updates the screen.

5.3.1 Main Screen Sharacter Control Data Write (If VSL = 0 in Command 0)

The main screen is placed in normal mode or graphic mode under control of the GRM bit of Command 9. Using a different operation mode partially changes the contents of commands.

[Command format]

Command 1-1 (Main screen character control data setting 1)

	MSB							LSB
First byte	1	0	0	0	1	MA	MB	AT
	MSB							LSB
Second byte	0	CG	CR	CB	MC	BG (GR)	BR (BS)	BB (MD) *

*: Parenthesized bit names are used for extended graphics mode.

Command 2-1 (Main screen character control data setting 2)

	MSB							LSB
First byte	1	0	0	1	0	M9	M8	M7
	MSB							LSB
Second byte	0	M6	M5	M4	M3	M2	M1	M0

(MD), MC to M0	: Character code
AT	: Specify character attribute display.
CG, CR, CB	: Character colors
BG, BR, BB	: Character background colors
(GR)	: Specify normal character/graphic character display.
(BS)	: Specify shaded background display.

[Function]

In normal mode, this command sets character codes, character colors, character background colors, and character attributes.

In extended graphic mode, this command sets character codes, character colors, normal or graphic character specification, character background display specification, transparency control, and color phase control.

[Description]

(1) In normal mode (Command 9: GRM = 0)

MC to M0 : Set a character code.
The character code can be specified between 0000_H to $1FFF_H$.
Up to 8192 different characters can be used.

AT : Specify character attribute display.
AT = 0 : Specify normal display.
AT = 1 : Specify attribute display.
Solid-fill background (when command 10: RB = 1)
Blinking (when command 10: BK = 1)
Shaded background (when command 1: BS = 1)

Note: If shaded background display and solid-fill background display or blinking display are specified, the shaded background display setting takes priority over the other setting.

CG, CR, CB : Character colors

BG, BR, BB : Character background colors

CG/BG	CR/BR	CB/BB	Character color signal output/Character background color signal output				
			Digital output			Video output	
			G	R	B	Color	Monochrome
0	0	0	L	L	L	Black	Gray 0 (Black)
0	0	1	L	L	H	Blue	Gray 1
0	1	0	L	H	L	Red	Gray 2
0	1	1	L	H	H	Magenta	Gray 3
1	0	0	H	L	L	Green	Gray 4
1	0	1	H	L	H	Cyan	Gray 5
1	1	0	H	H	L	Yellow	Gray 6
1	1	1	H	H	H	White	Gray 7 (White)

Note: The video output color of the character color signal is the one used when the color phase control of the main screen line control data is 0 degrees (Command 1-3: 0F1 = OF0 = 0). Control the OF1 and OF0 bits to display colors with the +90, +180, and +270 degree color phases.
Color/monochrome control of video output is performed with the CC and BC bits of Command 10.

(2) In extended graphics mode (Command 9: GRM = 1)

MD to M0 : Set a character code.
The character code can be specified between 0000_H to $3FFF_H$.
Up to 16384 different characters can be used.

AT : Specify character attribute display.
AT = 0 : Specify normal display.
AT = 1 : Turn attribute display ON.
Solid-fill background (when command 10: RB = 1)
Blinking (when command 10: BK = 1)
Shaded background (when command 1: BS = 1)

Note: If shaded background display and solid-fill background display or blinking display are specified, the shaded background display setting takes priority over the other setting.

GR : Specify normal character/graphic character display.
GR = 0 : Specify normal character display.
Characters made up of 24 horizontal dots × 32 vertical dots
GR = 1 : Specify graphic character display
Characters made up of 8 horizontal dots × 32 vertical dots (color settable for each dot)

Note: Do not set BS = 1.

BS : Specify shaded background display.
BS = 0 : Specify normal display.
BS = 1 : Specify shaded background display.
Characters for which AT = 0 has been set are shaded on the background.
Characters for which AT = 1 has been set are shaded on the background in reverse video.

1) In normal character display mode (GR = 0)

CG, CR, CB: Character colors

CG	CR	CB	Character color signal output				
			Digital output			Video output	
			G	R	B	Color (CC=1)	Monochrome (CC=0)
0	0	0	L	L	L	Black	Gray 0 (black)
0	0	1	L	L	H	Blue	Gray 1
0	1	0	L	H	L	Red	Gray 2
0	1	1	L	H	H	Magenta	Gray 3
1	0	0	H	L	L	Green	Gray 4
1	0	1	H	L	H	Cyan	Gray 5
1	1	0	H	H	L	Yellow	Gray 6
1	1	1	H	H	H	White	Gray 7 (white)

Note: The video output color is the one used when the color phase control of the main screen line control data is 0 degrees (Command 1-3: 0F1 = OF0 = 0). Control the OF1 and OF0 bits to display colors with the +90, +180, and +270 degree color phases.
Color/monochrome control of video output is performed with the CC bit of Command 10.

2) In graphic character display mode (GR = 1)

CG : Graphic color transparency control
CG = 0 : Normal display
CG = 1 : Transparent display
This setting replaces the “black” graphic color display with transparent display.

CR, CB : Graphic color phase control
These bits control the color phase of video signal outputs (VOUT pin and COUT pin outputs).

CR	CB	Graphic color phase
0	0	+0 degree
0	1	+90 degrees
1	0	+180 degrees
1	1	+270 degrees

5.3.2 Writing Sub-screen Line Control Data (When Command 0: VSL = 1, CA0 = 0)

Set sub-screen line control data.

[Command format]

Command 1-2 (Sub-screen line control data setting 1)

	MSB							LSB
First byte	1	0	0	0	1	SMA	SMB	0
	MSB							LSB
Second byte	0	SCG	SCR	SCB	SMC	SGR	SDC	SMD

Command 2-2 (Sub-screen line control data setting 2)

	MSB							LSB
First byte	1	0	0	1	0	SM9	SM8	SM7
	MSB							LSB
Second byte	0	SM6	SM5	SM4	SM3	SM2	SM1	SM0

SMD to SM0 : Sub-screen line first character code
SDC : Sub-screen line output control
SGR : Sub-screen line character display control
SCG to SCB : Sub-screen line character colors (when SGR = 0)
SCG : Sub-screen line graphic color transparency control (when SGR = 1)
SCR, SCB : Sub-screen line graphic color phase control (when SGR = 1)

[Function]

This command sets up the sub-screen for each line. The command sets the first character code of the sub-screen line, sub-screen line output, sub-screen line character display control, and sub-screen line character color.

[Description]

SMD to SM0:Sub-screen line first character code

Set the first character code of a sub-screen line. On this line, only characters with the continuous character codes can be displayed.
A value from 0000_H to $3FFF_H$ can be specified.

SDC: Sub-screen line output control
SDC = 0 : Disable sub-screen line display output.
SDC = 1 : Enable sub-screen line display output.

SGR: Sub-screen line character display control
SGR = 0 : Display normal characters.
SGR = 1 : Display graphic characters.

1) In sub-screen line normal character display mode (SGR = 0)

SCG to SCB: Sub-screen line character colors

SCG	SCR	SCB	Sub-screen line character color signal output				
			Digital output			Video output	
			G	R	B	Color (SCC=1)	Monochrome (SCC=0)
0	0	0	L	L	L	Black	Gray 0 (black)
0	0	1	L	L	H	Blue	Gray 1
0	1	0	L	H	L	Red	Gray 2
0	1	1	L	H	H	Magenta	Gray 3
1	0	0	H	L	L	Green	Gray 4
1	0	1	H	L	H	Cyan	Gray 5
1	1	0	H	H	L	Yellow	Gray 6
1	1	1	H	H	H	White	Gray 7 (white)

Note: Color/monochrome control of video output is performed with the SCC bit of Command 11.

2) In sub-screen line graphic character display mode (SGR = 1)

SCG : Sub-screen line graphic color transparency control
SCG = 0: Normal display
SCG = 1: Transparent display
This setting replaces “black” graphic color display with transparent display.

SCR, SCB : Sub-screen line graphic color phase control
These bits control the color phase of graphic character video signal outputs (VOUT pin and COUT pin outputs).

SCR	SCB	Sub-screen line graphic color phase
0	0	+0 degree
0	1	+90 degrees
1	0	+180 degrees
1	1	+270 degrees

5.3.3 Main Screen Line Control Data Write (If VSL = 1 and CA0 = 1 in Command 0)

This command sets the line control data of the main screen.

[Command format]

Command 1-3 (Main screen line control data setting 1)

	MSB							LSB
First byte	1	0	0	0	1	OF1	OF0	0
	MSB							LSB
Second byte	0	0	0	0	PC	PG	PR	PB

Command 2-3 (Main screen line control data setting 2)

	MSB							LSB
First byte	1	0	0	1	0	G2	G1	G0
	MSB							LSB
Second byte	0	SOC	VD	DG	KC	KG	KR	KB

OF1, OF0	: Character color phase control
PC	: Shaded pattern background color/monochrome control
PG, PR, PB	: Shaded pattern background color
G2, G1, G0	: Character size control
SOC	: Output priority control
VD	: Video signal output control
DG	: Digital signal output control
KC	: Line background color/monochrome control
KG, KR, KB	: Line background color

[Function]

This command sets the line control data of the main screen. For normal character display mode, the command sets the color phase control. For shaded background display mode, the command sets the pattern background color and its color/monochrome control, character size, display priority control between the main screen and the sub-screen, video output control, digital output control, and line background color and its color/monochrome control.

[Description]

OF1 and OF0: Character color phase control

In normal character display mode in normal mode or extended graphic mode, these bits control for each line the character color phase of the video signal output (VOUT pin and COUT pin output).

OF1	OF0	Character color phase
0	0	+0 degree
0	1	+90 degrees
1	0	+180 degrees
1	1	+270 degrees

PC : Shaded pattern background color/monochrome control (Valid only in extended graphics mode)

PC = 0 : Display the shaded pattern background of video signal outputs in monochrome.

PC = 1 : Display the shaded pattern background of video signal outputs in color.

PG, PR, PB: Shaded pattern background color (Valid only in extended graphics mode)

PG	PR	PB	Shaded pattern background color signal output				
			Digital output			Video output	
			G	R	B	Color (PC=1)	Monochrome (PC=0)
0	0	0	L	L	L	Black	Gray 0 (black)
0	0	1	L	L	H	Blue	Gray 1
0	1	0	L	H	L	Red	Gray 2
0	1	1	L	H	H	Magenta	Gray 3
1	0	0	H	L	L	Green	Gray 4
1	0	1	H	L	H	Cyan	Gray 5
1	1	0	H	H	L	Yellow	Gray 6
1	1	1	H	H	H	White	Gray 7 (white)

G2 to G0 : Character size

G2	G1	G0	Character size
0	0	0	Standard
0	0	1	Double width
0	1	0	Double width × double height
0	1	1	Quadruple width × double height
1	0	0	Standard
1	0	1	Double width
1	1	0	Double width × double height
1	1	1	Double height

SOC : Output priority control
SOC = 0 : Give display priority to the main screen.
This setting displays the main screen on top of the sub-screen.
SOC = 1 : Give display priority to the sub-screen.
This setting displays the sub-screen on top of the main screen.

VD : Video signal output control
VD = 0 : Disable output of main screen character information to the video output pin (VOUT, YOUT, or COUT pin).
VD = 1 : Output main screen character information to the video output pins (VOUT, YOUT, and COUT pins).

DG : Digital signal output control
DG = 0 : Disable output of main screen character information to the digital output pin (G, R, B, VOB, or VOC pin).
DG = 1 : Output main screen character information to the digital output pins (G, R, B, VOB, and VOC pins).

KC : Line background color/monochrome control
(Valid only in extended graphics mode)
KC = 0 : Display the line background of video signal outputs in monochrome.
KC = 1 : Display the line background of video signal outputs in color.

KG, KR, KB: Line background color
(Valid only in extended graphics mode)

KG	KR	KB	Line background color signal output				
			Digital output			Video output	
			G	R	B	Color (KC=1)	Monochrome (KC=0)
0	0	0	L	L	L	Black	Gray 0 (black)
0	0	1	L	L	H	Blue	Gray 1
0	1	0	L	H	L	Red	Gray 2
0	1	1	L	H	H	Magenta	Gray 3
1	0	0	H	L	L	Green	Gray 4
1	0	1	H	L	H	Cyan	Gray 5
1	1	0	H	H	L	Yellow	Gray 6
1	1	1	H	H	H	White	Gray 7 (white)

5.4 Command 3 (VRAM Write Control)

[Command format]

	MSB							LSB
First byte	1	0	0	1	1	FIL	0	0
	MSB							LSB
Second byte	0	0	0	0	0	0	0	0

FIL: VRAM fill control

[Function]

This command performs VRAM fill control.

[Description]

Before Command 1 or 2 writes data to VRAM, use this command to specify the VRAM fill so that the specified data is saved in the VRAM area from the current address to the end address.

FIL : VRAM fill control
FIL = 0: Do not fill VRAM.
FIL = 1: Fill VRAM.
Depending on the settings of the VSL and CA0 bits of Command 0, the main screen character control RAM, the main screen line control RAM, or the sub-screen line control RAM is selected.

VSL	CA0	Area to be filled
0	—	Main screen character control RAM
1	0	Sub-screen line control RAM
1	1	Main screen line control RAM

While VRAM fill is being executed, do not issue another command.

Note: VRAM fill is executed in about 1 ms if all the characters are set in the main screen character control RAM. The time it takes to set all the lines in the main screen line control RAM or sub-screen line control RAM is about 50 µs.
During external sync control, correct sync signals must be input.

5.5 Command 4 (Screen Control 1)

[Command format]

	MSB							LSB
First byte	1	0	1	0	0	IE	IN	EB

	MSB							LSB
Second byte	0	EO	CM	ZM	NP	P2	P0	DC

IE : Internal/external synchronization control
IN : Interlaced/noninterlaced display control
EB : Screen background display control
EO : Field control
CM : Color/monochrome display control
ZM : Zoom-in control
NP : NTSC/PAL control
P2, P0 : Pattern background control
DC : Display control

[Function]

This command controls sync signals and the screen.

[Description]

IE : Internal/external synchronization control
IE = 0 : Specify internal synchronization control operation.
IE = 1 : Specify external synchronization control operation.

IN : Interlaced/noninterlaced display control
IN = 0 : Specify interlaced scan display.
IN = 1 : Specify noninterlaced scan display.

Note: These settings are valid only during internal synchronization control operation. In external synchronization control operation, input sync signal scanning mode is used.

EB : Screen background display control
EB = 0: Specify normal display.
The screen background is displayed only during internal synchronization control operation.It is not displayed in external synchronization control operation.

EB = 1: Display the screen background.
The screen background is always displayed regardless of internal or external synchronization control.

EO : Field control
EO = 0: Specify normal display.
EO = 1: Replace display output data to the even-numbered and odd-numbered fields with each other.
Display output data to each field is replaced with that to the other when the horizontal/vertical separated sync signal input involves phase shift during external synchronization control operation.

CM : Color/monochrome display control
CM = 0: Monochrome display
The video signal output is in monochrome. The color burst signal is not output.
CM = 1: Color display
The video signal output is in color. Color synchronization with the external input video signal is required to enable a superimposed display in external synchronization control operation.

ZM : Zoom-in control
ZM = 0: Normal display
ZM = 1: Zoom into the main screen.
Only the upper 24 dots out of the 32 dots of the vertical character configuration are enlarged to double height.
Zoom-in display is not enabled in kanji font mode (RM0 = 1 or RM1 = 1 in Command 9).

NP : NTSC/PAL control
NP = 0: Output display signals using the NTSC system.
NP = 1: Output display signals using the PAL system.

Note: Also make the correct settings in external synchronization control operation.

P2, P0 : Pattern background control
Specify the pattern background mode for normal character display.

P2	P0	Pattern background mode
0	0	Pattern background 1
0	1	Pattern background 0
1	0	Pattern background 2
1	1	Pattern background 3

Figure 3 shows examples of pattern background display.

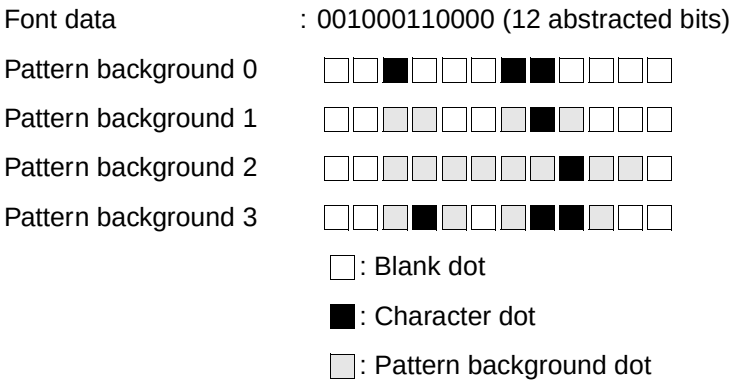


Figure 5.5-1 Pattern Background Display Examples

DC : Display control
DC = 0: Display neither the main screen nor the sub-screen.
Only the screen background can be displayed.
DC = 1: Enable display output operation.

5.6 Command 5 (Screen Control 2)

[Command format]

	MSB							LSB
First byte	1	0	1	0	1	KID	APC	GYZ

	MSB							LSB
Second byte	0	BH2	BH1	BH0	W3	W2	W1	W0

KID : Halftone control
APC : APC control
GYZ : Main screen line enlargement control
BH2 to BH0 : Color phase control
W3 to W0 : Main screen line spacing control

[Function]

This command performs halftone control, APC control, color phase control, and line enlargement control and line spacing control of the main screen.

[Description]

KID : Halftone control
KID = 0 : Perform normal display, disabling halftone display.
KID = 1 : Enable halftone display.
In superimposed display mode of external synchronization control operation (IE = 1 and EB = 0 in Command 4), the composite video signal (VIN-VOUT pin signal) displays the pattern and solid-fill backgrounds in halftones. It also displays the pattern and solid-fill backgrounds of the C signal (CIN-COUT pin signal) in gray scale. The level of the halftone background is determined by the resistor connected to the VKIN-VKOUT pins.

Note: In shaded background display, the solid-fill background and shading (black and white framing) are displayed in halftones, and not in the pattern background.

APC : APC control
APC = 0 : Turn the APC function OFF.
APC = 1 : Turn the APC function ON.
In superimposed display mode of external synchronization control operation (IE = 1 and EB = 0 in Command 4), the characters superimposed on the composite video signal (VIN-VOUT pin signal) and the C signal (CIN-COUT pin signal) can be displayed in color.

GYZ : Main screen line enlargement control
GYZ = 0 : Shift the display positions of the lines downward that follow a line on the main screen when that line is being displayed enlarged, to bring all the lines into view.
GYZ = 1 : Undisplay (conceal) the line that follows a line on the main screen when that line is being displayed enlarged, and display the remaining lines without changing their original positions.

BH2 to BH0 : Color phase control
With APC turned on, these bits are used for color phase control if there is a difference between the external input color phase and internal color phase for some reason such as a circuit delay.

BH2	BH1	BH0	Color phase offset
0	0	0	0 degree
0	0	1	45 degrees
0	1	0	90 degrees
0	1	1	135 degrees
1	0	0	180 degrees
1	0	1	225 degrees
1	1	0	270 degrees
1	1	1	315 degrees

W3 to W0 : Main screen line spacing control
Set the line spacing on the main screen.
The line spacing can be specified between 0 and 15 rasters in increments of one raster.

5.7 Command 6 (Main Screen Line Control)

[Command format]

	MSB							LSB
First byte	1	0	1	1	0	G2	G1	G0
	MSB							LSB
Second byte	0	SOC	VD	DG	N3	N2	N1	N0

G2 to G0 : Character size control
SOC : Output priority control
VD : Video signal output control
DG : Digital signal output control
N3 to N0 : Line specification

[Function]

This command performs character size control and output control for each line on the main screen.

[Description]

G2 to G0 : Character size control

G2	G1	G0	Character size
0	0	0	Standard
0	0	1	Double width
0	1	0	Double width × double height
0	1	1	Quadruple width × double height
1	0	0	Standard
1	0	1	Double width
1	1	0	Double width × double height
1	1	1	Double height

SOC : Output priority control
SOC = 0 : Give display priority to the main screen.
This setting displays the main screen on top of the sub-screen.
SOC = 1 : Give display priority to the sub-screen.
This setting displays the sub-screen on top of the main screen.

VD : Video signal output control
VD = 0 : Disable output of main screen character information to the video output pin (VOUT, YOUT, or COUT pin).
VD = 1 : Output main screen character information to the video output pins (VOUT, YOUT, and COUT pins).

DG : Digital signal output control
DG = 0 : Disable output of main screen character information to the digital output pin (G, R, B, VOB, or VOC pin).
DG = 1 : Output main screen character information to the digital output pins (G, R, B, VOB, and VOC pins).

N3 to N0 : Line specification
Specify the line on the main screen, for which control data is to be set.
The N3 to N0 bits correspond to the RA8 to RA5 bits for VRAM addresses.

5.8 Command 7 (Main Screen Vertical Display Position Control)

[Command format]

	MSB							LSB
First byte	1	0	1	1	1	EC	LP	FO
	MSB							LSB
Second byte	0	0	Y5	Y4	Y3	Y2	Y1	Y0

EC : Sync signal output control
LP : Simple NTSC/PAL control
FO : Color phase signal output control
Y5 to Y0 : Main screen vertical display position control

[Function]

This command performs sync signal control and main screen vertical display position control.

[Description]

EC : Sync signal output control
EC = 0 : Set the HSYNC pin as a composite sync signal output and the $\overline{\text{VSYNC}}$ pin as a fixed High-level output.
EC = 1 : Set the HSYNC pin as a horizontal sync signal output and the $\overline{\text{VSYNC}}$ pin as a vertical sync signal output.

LP : Simple NTSC/PAL control
LP = 0 : Normal operation
LP = 1 : Simple NTSC/PAL operation
In NTSC mode operation (NP = 0 in Command 4 and 4FSC clock = 14.31818 MHz), This bit enables PAL display operation (1V = 312.5H/312H).
In PAL mode operation (NP = 1 in Command 4 and 4FSC clock = 17.734475 MHz), this bit enables NTSC display operation (1V = 262.5H/263H).
Set CM = 0.

FO : Color phase signal output control
FO = 0 : Set the FSCO pin as a fixed Low-level output
FO = 1 : Set the FSCO pin to output the signal representing an internal color burst phase.

Y5 to Y0 : Main screen vertical display position control (in dot units)
This bit sets the vertical display position of the main screen using the number of H cycles (horizontal cycles) counted from the rise of the input vertical sync signal EXHSYN.

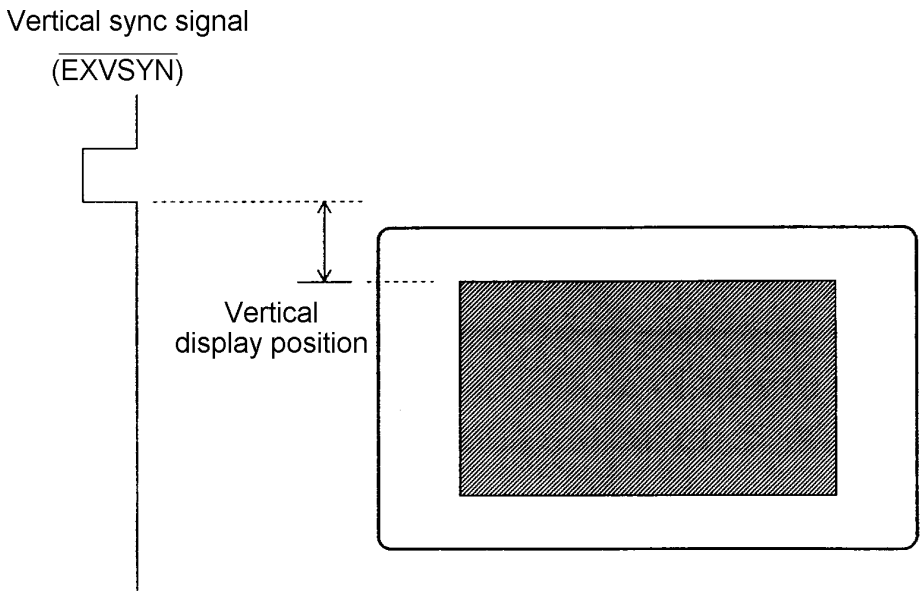


Figure 5.8-1 Main Screen Vertical Display Position

5.9 Command 8 (Main Screen Horizontal Display Position Control)

[Command format]

	MSB							LSB
First byte	1	1	0	0	0	SC	0	FC
	MSB							LSB
Second byte	0	0	X5	X4	X3	X2	X1	X0

SC : Sync signal input control
FC : Sync signal input 3 μs filter control
X5 to X0 : Main screen horizontal display position control

[Function]

This command performs sync signal input control and main screen horizontal display position control.

[Description]

SC : Sync signal input control bit
SC = 0 : Set the EXHSYN pin as a composite sync signal input and disable EXVSYN pin input.
SC = 1 : Set the EXHSYN pin as a horizontal sync signal input and the EXVSYN pin as a vertical sync signal input.

FC : Sync signal input 3 μs filter control
FC = 0 : Enable the 3 μs digital filter function of the EXHSYN pin input. The Low pulse signal inputs of 3 μs or less are ignored.
FC = 1 : Disable the 3 μs digital filter function of the EXHSYN pin input. The input signal drives the function directly.

X5 to X0 : Main screen horizontal display position control (in 8-dot units)
This bit sets the horizontal display position of the main screen using the number of dot clocks counted from the rise of the input horizontal sync signal (EXHSYN). This bit can be set in 8-dot (1/3 character) units and to a value from 00_H to $3F_H$. Figure 5.9-1 shows the relationship between the main screen horizontal display position and the horizontal sync signal.

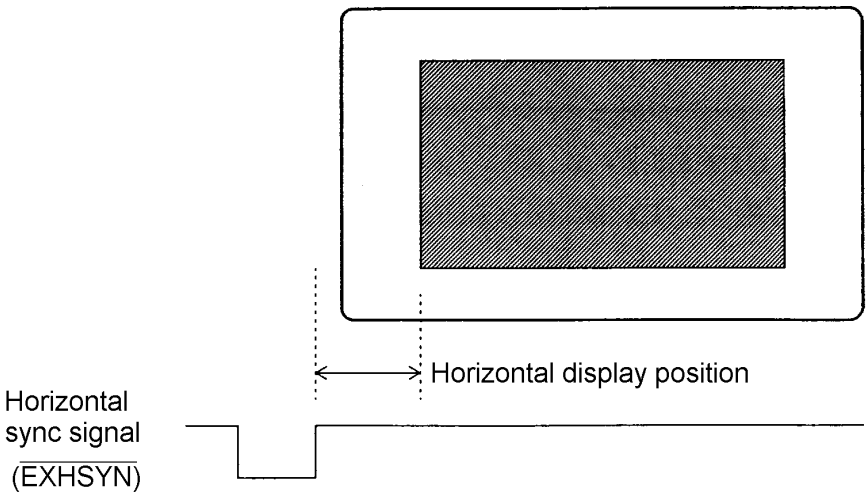


Figure 5.9-1 Main Screen Horizontal Display Position

5.10 Command 9 (Kanji Font Display Control)

[Command format]

	MSB							LSB
First byte	1	1	0	0	1	0	0	GRM
	MSB							LSB
Second byte	0	0	0	0	0	0	0	0

GRM : Main screen display mode control

[Function]

This command controls the main screen display mode and kanji font display.

[Description]

GRM : Main screen display mode control
GRM = 0 : Display the main screen in normal mode.
The main screen can display only normal characters.
The character background color can be set for each character.
GRM = 1 : Display the main screen in extended graphic mode.
The main screen can display both normal and graphic characters at the same time.

RP1 and 0 : Kanji font pattern background control
This bit specifies the pattern background mode for a character in the kanji font area.

PR1	PR0	Pattern background mode
0	0	Depends on the settings in P2 and P0 of Command 4.
0	1	Horizontal framing 1 (One-dot framing on the right and left sides of a character dot)
1	0	Horizontal framing 2 (Two-dot framing on the right and left sides of a character dot)
1	1	(Do not use this setting.)

Figure 5.10-1 shows examples of horizontal framing display.

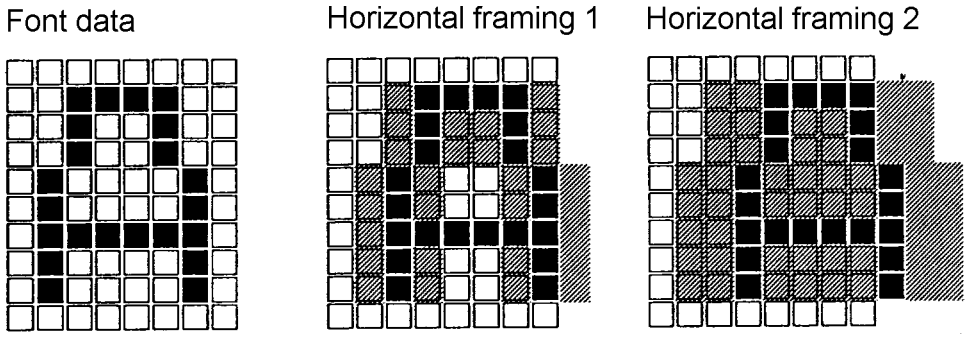


Figure 5.10-1 Examples of Horizontal Framing Display

Note: In horizontal framing 1, the character dot is shifted one dot to the right. In horizontal framing 2, the character dot is shifted two dots to the right.
If horizontal framing and a character in another display mode are adjacent, the display may not be correct.

S16: Kanji font 16/24-dot font control
S16 = 0: Select a 24-dot font.
A font of 24 by 24 dots is selected for a font in the kanji font area.
For the display format of a 24-dot font, see DW4 (kanji font vertical display position control).
S16 = 1: Select a 16-dot font.
A font of 16 by 16 dots is selected for a font in the kanji font area.
A 16-dot font is enlarged to double height and shifted 4 dots to the right.
Figure 5.10-2 shows a 16-dot font display format (example of one character).

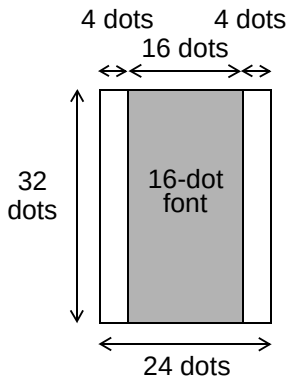


Figure 5.10-2 16-dot Font Display Format

Note: The DW4 specification is disabled.

SF1: Kanji font boldface character control
SF1 = 0: Perform normal display.
SF1 = 1: Bold a character in the kanji font area by enlarging the character dots horizontally by one dot. The character size is not changed.

Figure 5.10-3 shows an example of boldface character display.

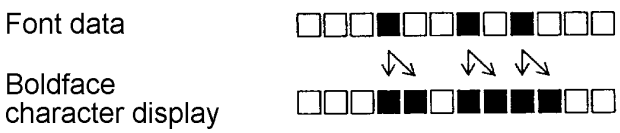


Figure 5.10-3 Example of Boldface Character Display (Fisplaying Twelve Fots in the Horizontal Direction)

Note: This specification replaces a non-character dot with a character dot, causing continuous display of the character dots.
Do not use this specification for a font created in relation to pattern backgrounds 1 and 2.

DW4: Kanji font display position control
DW4 = 0: Perform normal display.
The kanji font is displayed in the upper 24 dots of the 32 dots in the vertical direction.

DW4 = 1 : Shift a character in the kanji font area four dots down.

Note: This setting is valid only if S16 = 0 (using a 24-dot font).
Do not use this setting if S16 = 1.

Figure 5.10-4 shows a display format (example of one character).

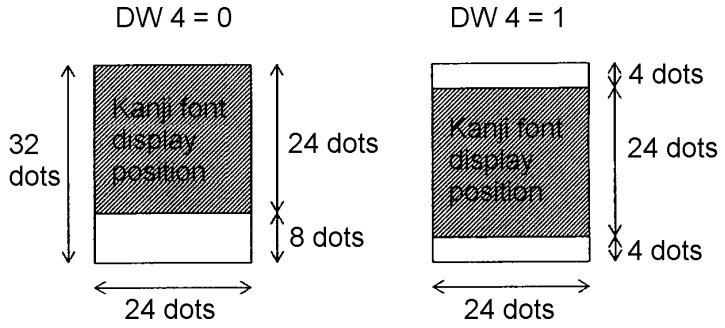


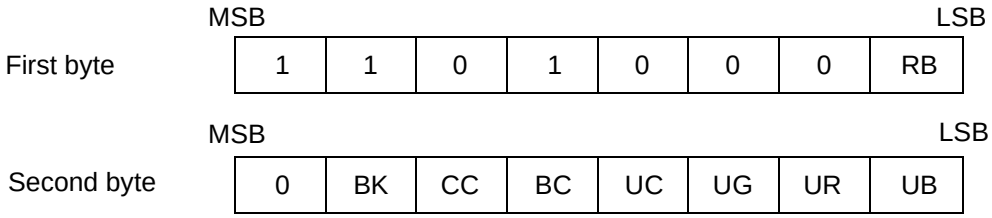
Figure 5.10-4 Kanji Font Display Position Format

RM1 and 0: Kanji font area control
This bit specifies the kanji font area.

RM1	RM0	Kanji font area control
0	0	No kanji font area (Using only normal characters)
0	1	Using 4M kanji font (Character codes: 0000_H to $0FFF_H$)
1	0	Using 8M kanji font (Character codes: 0000_H to $1FFF_H$)
1	1	(Do not use this setting.)

5.11 Command 10 (Color Control)

[Command format]



RB : Main screen solid-fill background display control
BK : Main screen blink display control
CC : Main screen character color/monochrome control
BC : Main screen character background color/monochrome control
(Main screen graphic color/monochrome control)
UC : Screen background color/monochrome control
UG, UR, UB : Screen background color

[Function]

This command performs, for the main screen, solid-fill background display control, blinking display control, character color and character background color/monochrome control, and screen background color setting, and screen background color/monochrome control.

[Description]

RB : Main screen solid-fill background display control
RB = 0 : Normal display
RB = 1 : The main screen is displayed with a solid-fill background.
This command displays a solid-fill background for a main screen character for which AT = 1 in Command 1-1.

Note: This specification displays a solid-fill background only for a normal character. A graphic character is displayed the normal way.
Shaded background display overrides this specification for a character for which BS = 1 in Command 1-1 (shaded background display character).
For a kanji ROM display character, the specification in RP1 and RP0 of Command 9 is used for priority control.

BK : Main screen blink display control
BK = 0 : Normal display
BK = 1 : Display characters blinking on the main screen.
This bit causes a main screen character for which AT = 1 in Command 1-1 to blink. The blinking cycle is about one second (on for 0.5 s and off for 0.5 s).
Both normal and graphic characters can blink.
The pattern background and the solid-fill background blink as well as the character.

Note: This specification is invalid for a character for which BS = 1 in Command 1-1 (shaded background display character).

CC : Main screen character color/monochrome control
CC = 0 : Display video signal output characters on the main screen in monochrome.
CC = 1 : Display video signal output characters on the main screen in color.

BC :(1) Main screen character background color/monochrome control (in normal mode with GRM = 0)
BC = 0 : Display the background of video signal output characters on the main screen in monochrome.
BC = 1 : Display the background of video signal output characters on the main screen in color.
(2) Main screen character background color/monochrome control (in extended graphics mode with GRM = 1)
BC = 0 : Display video signal output graphics on the main screen in monochrome.
BC = 1 : Display video signal output graphics on the main screen in color.

UC : Screen background color/monochrome control
UC = 0 : Display the video signal output screen background in monochrome.
UC = 1 : Display the video signal output screen background in color.

UG, UR, UB : Screen background color

UG	UR	UB	Screen background color signal output				
			Digital output			Video output	
			G	R	B	Color (UC=1)	Monochrome (UC=0)
0	0	0	L	L	L	Black	Gray 0 (black)
0	0	1	L	L	H	Blue	Gray 1
0	1	0	L	H	L	Red	Gray 2
0	1	1	L	H	H	Magenta	Gray 3
1	0	0	H	L	L	Green	Gray 4
1	0	1	H	L	H	Cyan	Gray 5
1	1	0	H	H	L	Yellow	Gray 6
1	1	1	H	H	H	White	Gray 7 (white)

5.12 Command 11 (Sub-Screen Control)

[Command format]

	MSB							LSB
First byte	1	1	0	1	1	SG2	SG1	SG0

	MSB							LSB
Second byte	0	0	SCC	SBC	SGC	SBG	SBR	SBB

SG2 to SG0 : Sub-screen configuration control
SCC : Sub-screen character color/monochrome control
SBC : Sub-screen character background color/monochrome control
SGC : Sub-screen graphic color/monochrome control
SBG, SBR, SBB : Sub-screen pattern background color

[Function]

This command performs sub-screen display control.

[Description]

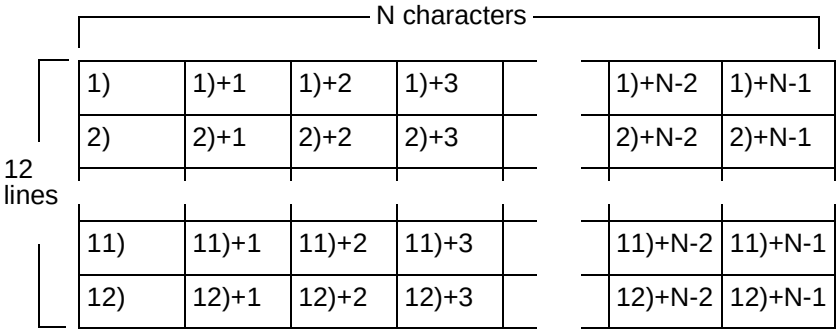
SG2 to SG0 : Sub-screen configuration control
Specify the display configuration of the sub-screen.

SG2	SG1	SG0	Sub-screen configuration
0	0	0	1 character × 12 lines
0	0	1	2 characters × 12 lines
0	1	0	4 characters × 12 lines
0	1	1	8 characters × 12 lines
1	0	0	16 characters × 12 lines
1	0	1	24 characters × 12 lines
1	1	0	32 characters × 12 lines
1	1	1	Full-screen display mode (32 characters × 16 lines)

If SG2 to 0 = 000 to 110 (normal screen mode), the first character can be specified for each line, and then as many characters with continuous character codes (addresses) as there are on-screen characters are displayed.

If SG2 to 0 = 111 (full screen mode), the full screen of 32 characters by 16 lines is displayed and controlled by SGA of Command 12.

Figure 5.12-1 shows the sub-screen configuration (in normal screen mode).



- 1) through 12) are any character codes (addresses).
- N is the number of characters in the horizontal direction in the sub-screen configuration according to the settings of SG2 to 0.

Figure 5.12-1 Sub-screen configuration

SCC : Sub-screen character color/monochrome control
SCC = 0 : Display video signal output characters on the sub-screen in monochrome.
SCC = 1 : Display video signal output characters on the sub-screen in color.

SBC : Sub-screen character background color/monochrome control
SBC = 0 : Display the background of video signal output characters on the sub-screen in monochrome.
SBC = 1 : Display the background of video signal output characters on the sub-screen in color.

SGC : Sub-screen graphic character color/monochrome control
SGC = 0 : Display video signal output graphic characters on the sub-screen in monochrome.
SGC = 1 : Display video signal output graphic characters on the sub-screen in color.

SBG, SBR, SBB : Sub-screen pattern background color
These bits specify the sub-screen pattern background colors.

SBG	SBR	SBB	Sub-screen pattern background color				
			Digital output			Video output	
			G	R	B	Color	Monochrome
0	0	0	L	L	L	Black	Gray 0 (black)
0	0	1	L	L	H	Blue	Gray 1
0	1	0	L	H	L	Red	Gray 2
0	1	1	L	H	H	Magenta	Gray 3
1	0	0	H	L	L	Green	Gray 4
1	0	1	H	L	H	Cyan	Gray 5
1	1	0	H	H	L	Yellow	Gray 6
1	1	1	H	H	H	White	Gray 7 (white)

5.13 Command 12 (Sub-Screen Vertical Position Control)

[Command format]

	MSB							LSB
First byte	1	1	1	0	0	SGA	0	SY7

	MSB							LSB
Second byte	0	SY6	SY5	SY4	SY3	SY2	SY1	SY0

SGA : Sub-screen full-screen mode control
SY7 to SY0 : Sub-screen vertical display position

[Function]

This command sets full screen mode control and the vertical display position of the sub-screen.

[Description]

SGA : Sub-screen full-screen mode control
Select a full-screen display mode for the sub-screen.
SGA = 0 : Full-screen mode A
Virtual screen : 32 characters × 16 lines × 32 screens
(Display screen capacity : 32 characters × 16 lines)
SGA = 1 : Full-screen mode B
Virtual screen : 512 characters × 32 lines
(Display screen capacity : 32 characters × 16 lines)

SY7 to SY0 : Sub-screen vertical display position (in 2-dot units)
These bits set the vertical display position of the sub-screen.
The vertical display position counted from the vertical sync pulse is set.
The vertical display position can be set to a value from 0 to 510 rasters in 2-raster units.

5.14 Command 13 (Sub-Screen Horizontal Position Control)

[Command format]

	MSB							LSB
First byte	1	1	1	0	1	0	SX8	SX7
	MSB							LSB
Second byte	0	SX6	SX5	SX4	SX3	SX2	SX1	SX0

SX8 to SX0 : Sub-screen horizontal display position

[Function]

This command sets the horizontal display position of the sub-screen.

[Description]

SX8 to SX0 : Sub-screen horizontal display position (in 2-dot units)

These bits set the horizontal display position of the sub-screen.

The horizontal display position counted from the horizontal sync pulse is set. The horizontal display position can be set to a value from 0 to 1022 dots in 2-dot units.

CHAPTER 6 APPLICATIONS

This chapter shows application examples which may serve as a guide when designing your system using the MB90092.
The circuits shown here are just examples and must, therefore, be carefully evaluated before actually using them in your application system.
The contents described here are not guaranteed in terms of performance when applied to products available on the market, and do not assure that they meet any specific purposes of use.

6.1 Power Supply
6.2 VIN and YIN Circuits
6.3 VOUT and YOUT Circuits
6.4 CIN and COUT Circuit
6.5 VKIN and VKOUT Circuits
6.6 Interfacing with Microcontroller
6.7 Refreshing Display Data
6.8 Handling Unused Pins

6.1 Power Supply

The MB90092 has two systems of power supply and grounding pins for digital circuits (Vcc and Vss) and analog circuits (AVcc1, AVcc2, and AVss). Inside the chip, the power pins Vcc, AVcc1, and AVcc2 are independent and the grounding pins Vss and AVss are common.

Special considerations different from the digital circuit power supply are required for the analog circuit power supply, which also supplies power to the analog switch with which character information is superimposed on video signals.

In general, pay attention to the following points:

- Design so that the ground and the power supply will have a low impedance. We recommend that the grounding line including the circumferential analog circuits be connected directly to a wide ground plane.
- Provide separate power sources for the digital circuit (Vcc and Vss) and analog circuit (AVcc1, AVcc2, and AVss). Do not cause a difference in potential between Vcc-AVcc1-AVcc2 and Vss-AVss.
  If the same power source is used to supply power to the analog and digital circuits, use independent cables from the power source. Also, use a choke coil, etc., to prevent an inflow of digital noise via the power source.
- In each of the digital and analog circuits, install a relatively high-capacity (about a few tens to 100 μF) electrolytic capacitor as a bypass capacitor between the power supply and ground.

■ Not Using any of the Analog Circuit Functions

If none of the analog circuit functions (*1) are to be used, we recommend the AVcc1, AVcc2, and AVss terminals be connected to the Vss level. This will reduce the current consumption of the analog circuit.

*1 Analog circuit functions include the functions of the VIN, VOUT, YIN, YOUT, CIN, COUT, VKIN, and VKOUT pins.

■ Using only the Composite Sync Signal Input and Output Function of the Analog Circuit Functions.

If from among the analog circuit functions only the VIN, VOUT, VKIN, and VKOUT pin functions and none of the YIN, YOUT, CIN, and COUT pin functions are to be used, we recommend that AVcc1 be connected to the power supply and AVcc2 be connected to the AVss (Vss) level. This will prevent unnecessary consumption of analog power.

6.2 VIN and YIN Circuits

The VIN and YIN pins must have as their input a DC-restored (clamped) 2Vp-p video signal.

Figure 6-2-1 shows an example of a video signal DC-restoring (clamping) circuit.

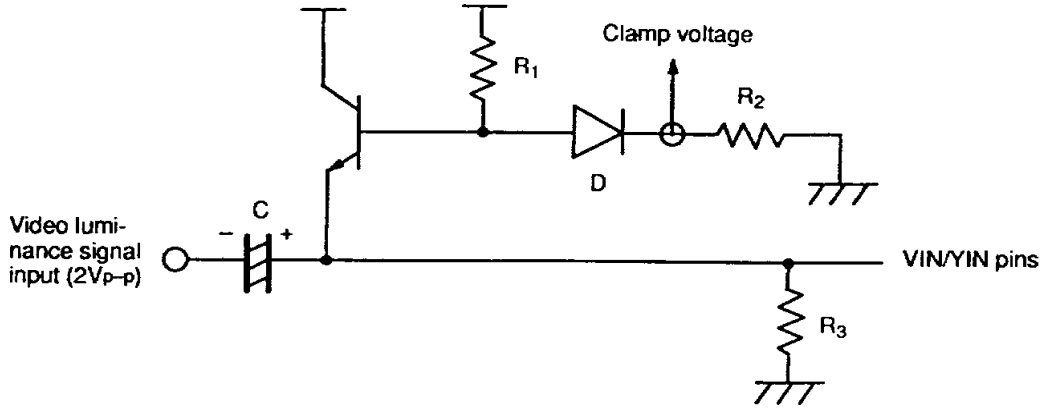


Figure 6.2-1 DC-Restoring (Clsmping) Circuit

In the circuit shown in Figure 6-2-1, the video signal sync tip (tip of sync signal) level is clamped to the voltage set by R_1 and R_2 (see Figure 6-2-2).

The time constant of C and R_3 must be sufficiently larger than the vertical period of the video signal (approx. 17 ms).

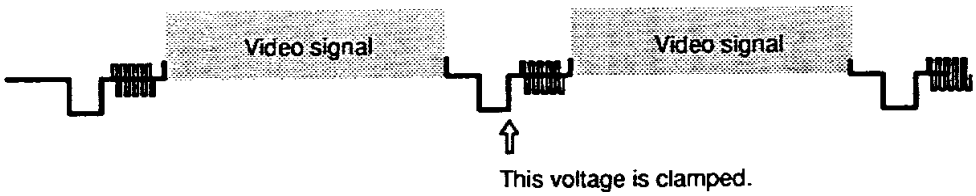


Figure 6.2-2 Sync Tip Clamp

6.3 VOUT and YOUT Circuits

The VOUT and YOUT pins have the MB90092's internal analog switches directly connected to them, so that the signals from these pins must be received with high impedance. Generally, the signals are output via an emitter follower buffer circuit shown in Figure 6-3-1.

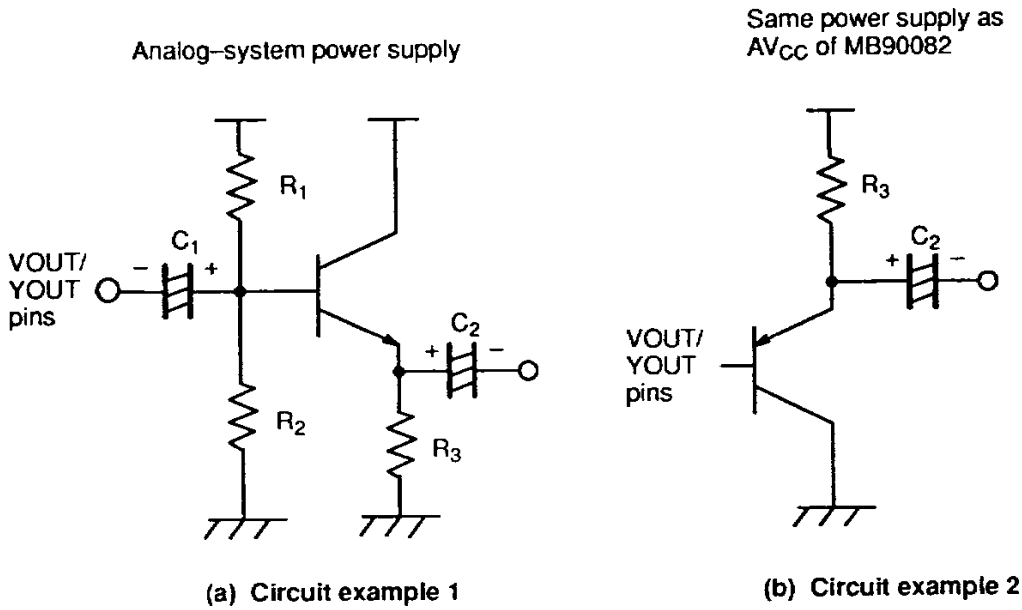
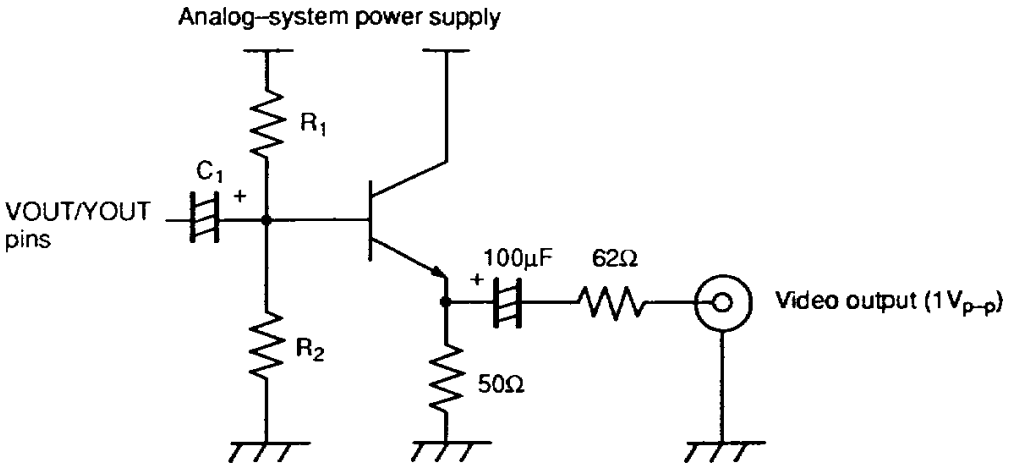


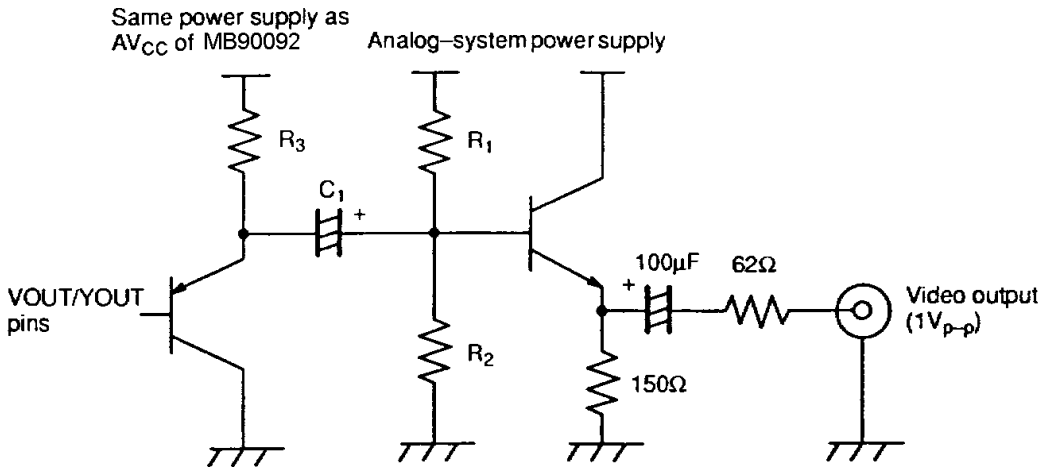
Figure 6.3-1 Emitter Follower Buffer Circuit

When driving a video output line of 75-ohm impedance, circuit (a) in Figure 6-3-2 may be used for most practical purposes. When the effects of the analog switches on the video signal are considered, however, it is desirable to receive the output from the VOUT/YOUT pins with as much high impedance as possible, so circuit (b) in Figure 6-3-2 is recommended.



(a) Video output circuit example 1

Figure 6.3-2 Video Output Circuit Examples



(b) Video output circuit example 2

Figure 6.3-2 Video Output Circuit Examples *(Continued)*

6.4 CIN and COUT Circuit

Figure 6-4-1 shows a circuit example for the CIN pin; Figure 6- 4-2 shows a circuit example for the COUT pin.

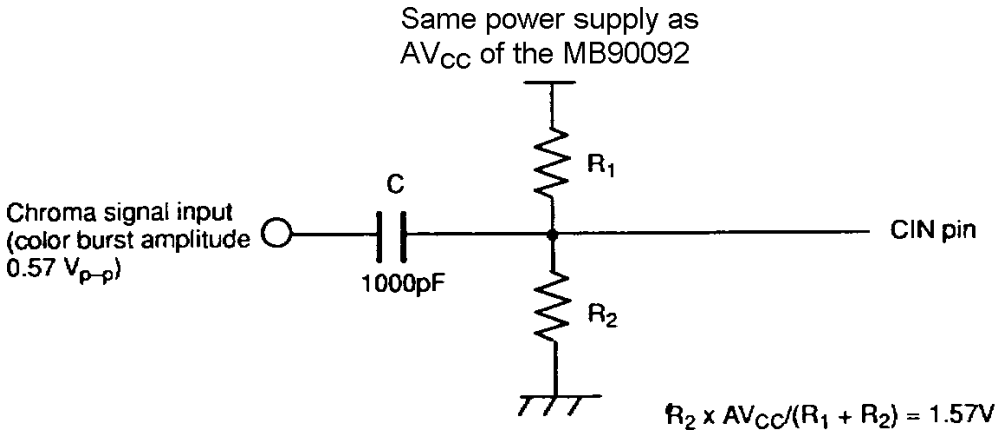


Figure 6.4-1 Circuit Example for CIN Pin

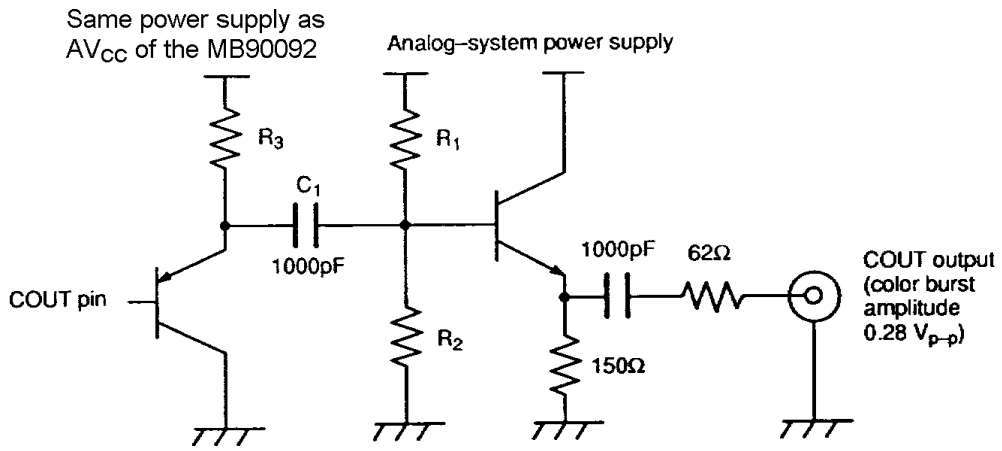


Figure 6.4-2 Circuit Example for COUT Pin

6.5 VKIN and VKOUT Circuits

In superimposed display mode for composite video signals, you can have the MB90092 adjust the intensity level of input video signals to output these signals instead of outputting the pattern background and solid-fill background at the internally generated intensity level. This display format is called halftone background display.

Figure 6.5-1 shows a circuit example for the VKIN and VKOUT pins used to perform halftone background display.

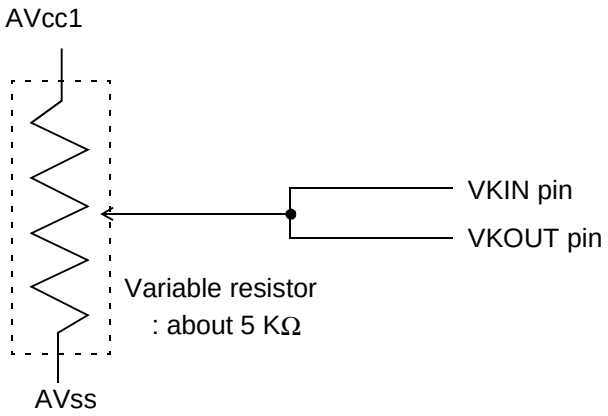


Figure 6.5-1 Circuit Example for VKIN and VKOUT Pins

6.6 Interfacing with Microcontroller

The MB90092 operation is controlled by a microcontroller. The MB90092 is interfaced with the microcontroller via 8-bit serial transfer. The three signal lines shown in Figure 6-6-1 are used for this interface.

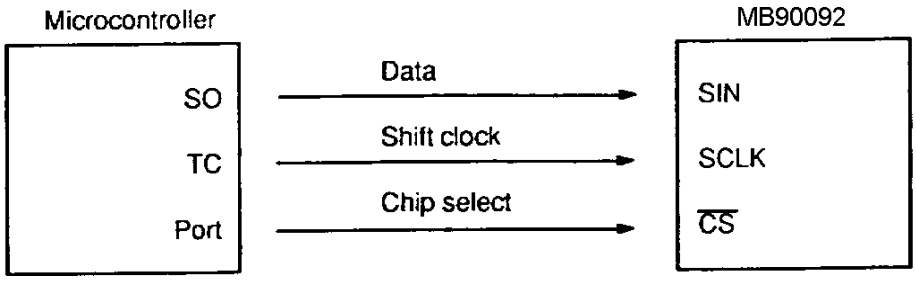


Figure 6.6-1 Interface with Microcontroller

Although any type of microcontroller may be used, those with an 8-bit serial interface (8-bit serial port) can be directly connected to the MB90092 so commands and data can be transferred by hardware at high speed. (Microcontrollers with 4-bit serial ports may also be used, in which case data is transferred in two operations.)

Note: Some microcontrollers cannot be directly connected to the MB90092 serial ports. Fujitsu's 4/8-bit microcontrollers may be used without any problem.

6.7 Refreshing Display Data

The register data set via serial transfer and the VRAM data are retained as long as the MB90092 remains powered on. However, it is recommended that the display data be periodically refreshed to prevent the data from being disturbed by external noise during serial transfer or erroneous display due to some other reason.

For refreshing display data, write the data (all data including the blank character code) to VRAM and settings by all commands repeatedly at a period of several ten milliseconds to several seconds.

When writing data to VRAM, it is effective to execute write address preset by command 0 in units of rows.

6.8 Handling Unused Pins

Handle unused MB90092 pins as shown in Table 6.8-1.

Table 6.8-1 Handling of Unused Pins

Pin name	Pin number	Input or output	Handling of a pin that is not used
$\overline{TC}$	1	Input	Connect the pin to Vcc.
VOC	2	Output	Leave the pin open.
VOB	3	Output	Leave the pin open.
Vss	4	Power supply	-
B	5	Output	Leave the pin open.
R	6	Output	Leave the pin open.
G	7	Output	Leave the pin open.
$\overline{CS}$	8	Input	-
SCLK	9	Input	-
SIN	10	Input	-
Vcc	11	Power supply	-
$\overline{EXHSYN}$	12	Input	Connect the pin to Vcc or leave it open.
$\overline{EXVSYN}$	13	Input	Connect the pin to Vcc or leave it open.
$\overline{HSYNC}$	14	Output	Leave the pin open.
$\overline{VSYNC}$	15	Output	Leave the pin open.
$\overline{VBLNK}$	16	Output	Leave the pin open.
EXS	17	Input	-
XS	18	Output	-
[N.C]	19		Leave the pin open.
FSCO	20	Output	Leave the pin open.
CBCK	21	Input	Connect the pin to Vcc or Vss or leave it open.
PDS	22	Output	Leave the pin open.
Vss	23	Power supply	-
AVss	24	Power supply	-
[N.C]	25		Leave the pin open.
[N.C]	26		Leave the pin open.
[N.C]	27		Leave the pin open.
[N.C]	28		Leave the pin open.

Table 6.8-1 Handling of Unused Pins *(Continued)*

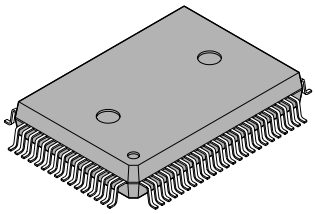
Pin name	Pin number	Input or output	Handling of a pin that is not used
AVss	29	Power supply	-
AVss	30	Power supply	-
YOUT	31	Output	Leave the pin open.
YIN	32	Input	Connect the pin to AVss (Vss).
AVcc2	33	Power supply	Connect the pin to AVss (Vss).
COUT	34	Output	Leave the pin open.
CIN	35	Input	Connect the pin to AVss (Vss).
AVss	36	Power supply	-
VOUT	37	Output	Leave the pin open.
VIN	38	Input	Connect the pin to AVss (Vss).
VKOUT	39	Output	Leave the pin open.
VKIN	40	Input	Connect the pin to AVss (Vss).
AVcc1	41	Power supply	Connect the pin to AVss (Vss).
Vcc	42	Power supply	-
$\overline{\text{READ}}$	43	Output	-
DA0	44	Input	-
DA1	45	Input	-
DA2	46	Input	-
DA3	47	Input	-
DA4	48	Inputt	-
DA5	49	Input	-
DA6	50	Input	-
DA7	51	Input	-
Vss	52	Power supply	-
ADR0	53	Output	-
ADR1	54	Output	-
ADR2	55	Output	-
ADR3	56	Output	-
ADR4	57	Output	-
ADR5	58	Output	-

Table 6.8-1 Handling of Unused Pins *(Continued)*

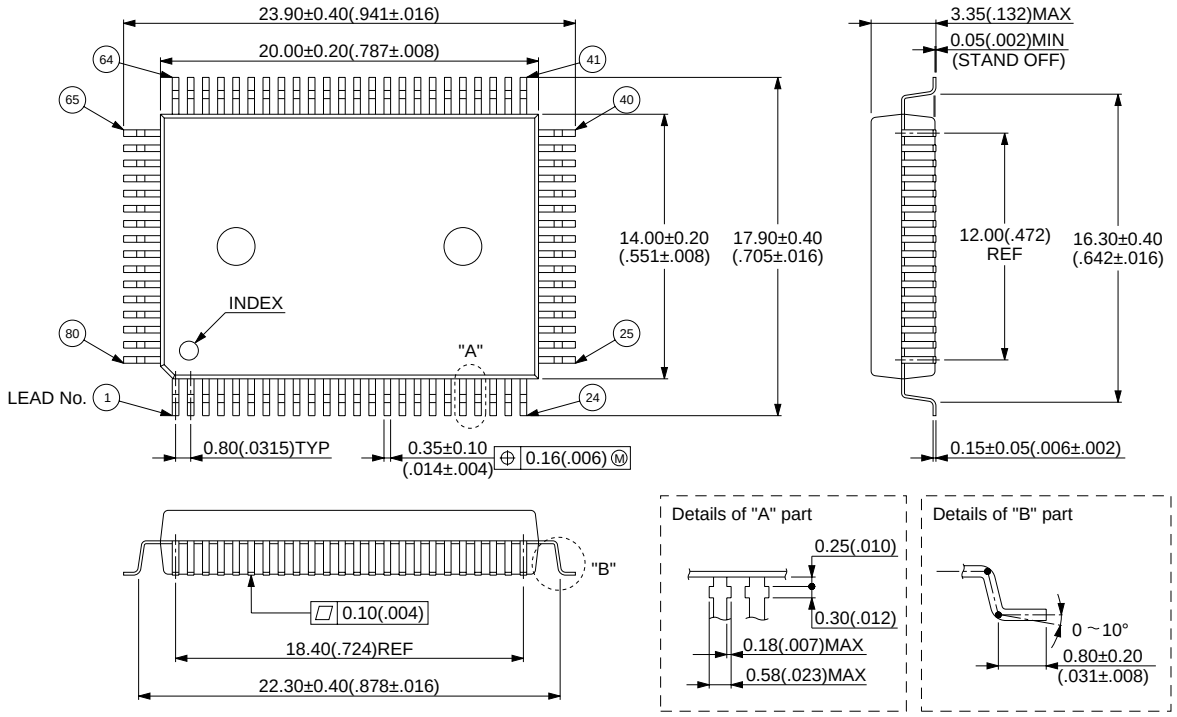
Pin name	Pin number	Input or output	Handling of a pin that is not used
ADR6	59	Output	-
ADR7	60	Output	-
ADR8	61	Output	-
Vcc	62	Power supply	-
ADR9	63	Output	-
ADR10	64	Output	-
Vss	65	Power supply	-
ADR11	66	Output	-
ADR12	67	Output	-
ADR13	68	Output	-
ADR14	69	Output	Leave the pin open.
ADR15	70	Output	Leave the pin open.
ADR16	71	Output	Leave the pin open.
ADR17	72	Output	Leave the pin open.
ADR18	73	Output	Leave the pin open.
ADR19	74	Output	Leave the pin open.
ADR20	75	Output	Leave the pin open.
Vcc	76	Power supply	
$\overline{\text{TSC}}$	77	Input	Connect the pin to Vcc.
$\overline{\text{TEST}}$	78	Input	Connect the pin to Vcc.
EXD	79	Input	-
XD	80	Output	-

FPT-80P-M06

EIAJ code: *QFP080-P-1420-4

80-pin plastic QFP  (FPT-80P-M06)		
	Lead pitch	0.80 mm
	Package width and length	14 x 20 mm
	Lead form	Gull-wing
	Packaging	Plastic mold
	Pin flat portion length	0.80 mm

80-pin Plastic QFP
(FPT-80P-M06)



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■ Display color configuration chart

		Main screen (GRM = 0: normal mode)		
		Color display	Monochrome display	Color/monochrome specification
Character color	(C)	8 colors (for each character) x 4 phases (for each line) (CG, CR, CB) x (OF1, OF0)	8 gradient colors (for each character) (CG, CR, CB)	Specification for entire screen (CC)
Pattern background color	(B)	8 colors (for each character) (BG, BR, BB)	8 gradient colors (for each character) (BG, BR, BB)	Specification for entire screen (BC)
Solid-fill background color				

		Main screen (GRM = 1: extended graphic mode)		
		Color display	Monochrome display	Color/monochrome specification
Character color	(C)	8 colors (for each character) x 4 phases (for each line) (CG, CR, CB) x (OF1, OF0)	8 gradient colors (for each character) (CG, CR, CB)	Specification for entire screen (CC)
Line pattern background color	(K)	8 colors (for each line) (KG, KR, KB)	8 gradient colors (for each line) (KG, KR, KB)	Specification for each line (KC)
Line solid-fill background colorr				
Shaded pattern background color	(P)	8 colors (for each line) (PG, PR, PB)	8 gradient colors (for each line) (PG, PR, PB)	Specification for each line (PC)
Graphic color (External data)		8 colors (for each dot) x 4 phases (for each character) (External data: 3 bits) x (CR, CB)	8 gradient colors (for each dot) (External data: 3 bits)	Specification for entire screen (BC)

	Sub-screen (SG2 to 0 = value other than 111: normal screen mode)		
	Color display	Monochrome display	Color/monochrome specification
Character color (SC)	8 colors (for each line) (SCG, SCR, SCB)	8 gradient colors (for each line) SCG, SCR, SCB)	Specification for entire screen (SCC)
Pattern background color (SB)	8 colors (for entire screen) (SBG, SBR, SBB)	8 gradient colors (for entire screen) (SBG, SBR, SBB)	Specification for entire screen (SBC)
Graphic color (External data)	8 colors (for each dot) x 4 phases (for each line) (External data: 3 bits) x (SCR, SCB)	8 gradient colors (for each dot) (External data: 3 bits)	Specification for entire screen (SGC)

	Sub-screen (SG2 to 0 = 111: full screen mode)		
	Color display	Monochrome display	Color/monochrome specification
Character color (C)	8 colors (for entire screen) (SCG, SCR, SCB first line)	8 gradient colors (for entire screen) (SCG, SCR, SCB first line)	Specification for entire screen (SCC)
Pattern background color (SB)	8 colors (for entire screen) (SBG, SBR, SBB)	8 gradient colors (for entire screen) (SBG, SBR, SBB)	Specification for entire screen (SBC)
Graphic color (External data)	8 colors (for each dot) x 4 phases (for entire screen) (External data: 3 bits) x (SCR, SCB first line)	8 gradient colors (for each dot) (External data: 3 bits)	Specification for entire screen (SGC)

	Screen background		
	Color display	Monochrome display	Color/monochrome specification
Screen background color (U)	8 colors (for entire screen) (UG, UR, UB)	8 gradient colors (for entire screen) (UG, UR, UB)	Specification for entire screen (UC)

■ Main Screen Nnormal Character Display Format Chart

Screen No.	Command 9 (Setting for entire screen)	Command 10 (Setting for entire screen)		Command 1 (Setting for each character)		Display format	Pattern back-ground color	Solid-fill back-ground color
	GRM	RB	BK	BS	AT			
(1)	0 (Normal mode)	0	0	-	0	Pattern background display	B	-
					1	Pattern background display	B	-
(2)			1		0	Pattern background display	B	-
					1	Pattern background and blinking display	B	-
(3)		1	0		0	Pattern background display	B	-
					1	Solid-fill background display	-	B
(4)			1		0	Pattern background display	B	-
					1	Solid-fill background and blinking display	-	B
(5)	1 (Extended graphic mode)	0	0	0	0	Pattern background display	K	-
					1	Pattern background display	K	-
				1	0	Shaded pattern background display	P	K
					1	Reverse shaded pattern background display	P	K
(6)			1	0	0	Pattern background display	K	-
					1	Pattern background and blinking display	K	-
				1	0	Shaded pattern background display	P	K
					1	Reverse shaded pattern background display	P	K
(7)		1	0	0	0	Pattern background display	K	-
					1	Solid-fill background display	-	K
				1	0	Shaded solid-fill background display	-	K
					1	Reverse shaded solid-fill background display	-	K
(8)			1	0	0	Pattern background display	K	-
					1	Solid-fill background and blinking display	-	K
				1	0	Shaded solid-fill background display	-	K
					1	Reverse shaded solid-fill background display	-	K

- The pattern background depends on the specifications of the P0 and P2 bits of Command 4 and the RP0 and RP1 bits of Command 9.
- In blinking display, a character as well as its pattern background and solid-fill background blink.
- In pattern background and solid-fill background columns, B, K, and P mean the following:

  B: Character background color (BG, BR, and BB)

  K: Line background color (KG, KR, and KB)

  P: Shaded pattern background (PG, PR, and PB)
- A display screen for each screen number can be configured.

AM32-10827-1E

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ON-SCREEN DISPLAY CONTROLLER

ASSP FOR SCREEN DISPLAY CONTROLLER

MB90092

USER'S MANUAL

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